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SURVEY OF THE YAZOO RIVER WATERSHED
IN MISSISSIPPI

LETTER

FROM THE

ACTING SECRETARY OF AGRICULTURE

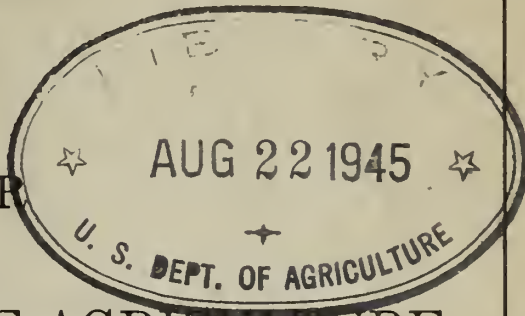
TRANSMITTING

A REPORT OF A SURVEY OF THE YAZOO RIVER WATERSHED
IN MISSISSIPPI DESCRIBING AN INVESTIGATION OF A
PROGRAM OF WATERFLOW RETARDATION AND SOIL
EROSION PREVENTION IN AID OF FLOOD CONTROL,
MADE PURSUANT TO THE FLOOD CONTROL ACT
OF JUNE 22, 1936



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WASHINGTON : 1944



LETTER OF TRANSMITTAL

DEPARTMENT OF AGRICULTURE,
Washington, April 27, 1944.

The Honorable the SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: There is transmitted herewith a report of a survey of the Yazoo River watershed in Mississippi, made by this Department pursuant to the Flood Control Act of June 22, 1936.

The report describes an investigation of a program of waterflow retardation and soil-erosion prevention in aid of flood control. A program of this kind, pursuant to the flood-control acts, is recommended for installation in the watershed.

We have been advised by the Bureau of the Budget that while there would be no objection to the submission of the proposed report to the Congress, it should be understood that no commitment would thereby be made as to any early financing of a land-use and management program for the Yazoo River watershed in Mississippi.

Sincerely,

GROVER B. HILL,
Acting Secretary.



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FLOOD CONTROL SURVEY REPORT—YAZOO RIVER WATERSHED, MISSISSIPPI

Presenting a Program of Watershed Treatments, Including Measures To Retard Run-off and Prevent Soil Erosion for the Control of Floods on Valley Lands

SUMMARY

The Yazoo River Basin of some 5,696,000 acres, drains the north-western one-quarter of the State of Mississippi. The eastern part of the watershed comprises undulating to hilly uplands with numerous broad valleys. The western half of the basin, the Yazoo delta, is a level alluvial plain which was shared originally with the Mississippi River. Four major tributaries, the Coldwater, Tallahatchie, Yocona, and Yalobusha Rivers drain the uplands and two sluggish streams, the Sunflower River and Steele Bayou, drain the delta.

The Yazoo Basin has suffered flood damage since its history has been recorded. Prior to construction of the main Mississippi River levee, major Mississippi River floods inundated a large part of the delta. Even at present about a million acres in the lower delta are subject to Mississippi backwater overflow.

Headwater floods originating in the Coldwater, Tallahatchie, Yocona, and Yalobusha Rivers are more frequent and damaging than Mississippi backwater.

Future flood and sedimentation damage, in the absence of remedial measures, is estimated at approximately \$3,187,000 annually.¹ Of the \$2,550,000 direct flood damage, \$1,800,000 is caused by floodwater and \$750,000 is caused by flood-borne sediment. About \$637,000 damage is caused indirectly by flooding and sedimentation. Most of the damage is suffered by farmers and most of the farm loss is due to reduction in crop yields.

Almost 20 percent of the entire upland area is subject to flood and sediment damage. Lands in the tributary valleys are not infrequently overflowed 10 to 15 times in a single year and 24 floods have been experienced in a year on 1 tributary. The bottom lands along the main upland streams are overflowed at least once each year and in some years several floods are experienced.

Floods occurred in the past, even before settlement, but the frequency and severity of flooding have increased during the past century. Two readily apparent circumstances are responsible for more severe flooding, greater storm run-off and choked stream channels. These are sedimentation and increased surface run-off.

The fertile upland soils are subject to excessive erosion when exposed. The original forest cover prevented all but incipient erosion,

¹ Not included is \$1,200,000 annual damage in the Little Tallahatchie River Basin. This situation is discussed in H. Doc. 892, 77th Cong., 2d sess., 1942.

but after clearing and the establishment of cotton as the predominant crop, the soil has been left uncovered for much of the year. In consequence, some stream channels are completely filled with the eroded material and the capacity of the upland soils to absorb the rains has been reduced. Conditions are now so severe that a rain of less than an inch may cause damaging flooding.

The flood-control program herein proposed by the Department of Agriculture will yield flood and sedimentation-control benefits having an annual value of \$1,675,600. Furthermore measures employed in reducing floodwater at its source are all beneficial to crops, both field and forest, and private annual income will be enhanced by \$5,487,200. To be added to this would be \$968,600 benefits to public agencies, largely in the form of increased income from lands to be acquired. Total annual benefits thus are over \$8,131,400.

The proposed program, which could be completely installed in 20 years or less, involves the treatment of 2,353,000 acres or 80 percent of all rural lands in the upland portion of the watershed.

One of the most essential features of the program is public purchase of some 730,000 acres of submarginal farm land. This land, much of it now abandoned, is so badly deteriorated and its productive and sustaining power is so low that under private ownership it could not possibly carry the cost of the required remedial measures. Revegetation of about 170,000 acres of submarginal land, including 47,000 of badly gullied land also requiring special erosion control measures, is essential. Forest management practices required to regain an adequate cover for optimum water retention and erosion prevention, will be inaugurated on 1,176,000 acres, including 532,000 acres to remain in private ownership. Fire control will be established or strengthened as required on more than 1½ million acres of private and public forest lands.

Soil- and water-conservation measures, including terracing, crop rotations, and winter cover crops, will be applied to 269,000 acres of cropland. About 382 miles of diversion terraces will be constructed to protect croplands against damaging run-off from adjacent land. Protective perennial vegetation will be established on 54,000 acres of more seriously eroded cropland. The water-holding and soil-protecting capacity of 407,000 acres of pasture land will be improved by contour furrowing, fertilizing, seeding and planting, and related measures.

Road-bank erosion and run-off will be controlled on 4,950 miles of public roads by establishment of protective and permanent vegetation.

The cost of installation of the watershed program to the Federal Government will be \$21,725,000, to the State and local governments \$1,200,000, and to private individuals \$2,350,000, or a total over-all cost of \$25,275,000.

Installation and maintenance costs will total approximately \$50,500,000 for the 20-year installation period. The cost to the Federal Government will total approximately \$26,300,000, to State and local governments about \$1,250,000, and to private individuals approximately \$23,000,000. After the installation period, the annual cost to the Federal Government for maintenance and supervision will

be \$485,300, to State and local governments \$16,300, and to private individuals nearly \$2,000,000. Of the total cost during this period, approximately 50 percent is carried by the Federal Government; after this period, approximately 80 percent will be carried by private individuals.

When the various costs are discounted according to time of occurrence and then converted to an annual basis the average annual cost to the Federal Government is \$1,064,500, to State and local government it is \$47,100, and to private individuals it is \$2,453,800. This makes a total annual cost of approximately \$3,565,400.

Annual benefits amount to \$2.28 per \$1 of cost for the entire watershed. Flood and sediment reduction benefits amount to \$1.57 per \$1 of annual Federal costs. Private on-site benefits amount to \$2.24 for each \$1 of private cost.

In consideration of the favorable ratio of benefit to costs, public and private alike, execution of the described remedial program under flood-control legislation is recommended.

CHAPTER I. DESCRIPTION OF THE WATERSHED

The Yazoo River drains most of the northwest quarter of the State of Mississippi. Approximately three-quarters of the watershed is undulating to hilly uplands dissected by numerous and comparatively broad valleys. The uplands drain into the western part of the watershed, an almost level, alluvial plain of the Mississippi River known locally as the Yazoo delta. Various tributary streams converge in the delta into the Yazoo River, which enters the Mississippi River at Vicksburg.

The portion of this watershed above Yazoo City, and particularly the uplands east of the Yazoo delta, is an area of serious land misuse responsible for most of the flood problems.² This upland area is less than half forested and sustains an exploitative and dwindling agricultural economy. Although the plan for reducing run-off and preventing erosion applies to upland area, the flood problems and potential benefits applicable to the Yazoo delta have also been appraised.³

Four major streams—the Coldwater, Tallahatchie, Yocona, and Yalobusha Rivers—drain the uplands. Works planned by the United States Engineer Department, consisting of flood-control reservoirs, augmented by such channel improvements and levees as are necessary below the reservoirs,⁴ will prevent serious flooding of the Yazoo delta by these streams. Some smaller streams drain into the main rivers below existing or proposed reservoirs and others drain directly into the delta. The main stream systems and flood-control reservoirs divide the watershed into natural drainage units which readily lend themselves to study and analysis of treatment needs (table 1 and fig. 1).

² A portion of the upland area, the Little Tallahatchie River above Sardis Dam, has been previously reported upon (H. Doc. 892, 77th Cong., 2d sess.). It embraces an area of 988,800 acres, which is eliminated from consideration in this report. However, data for this watershed are occasionally shown for comparative purposes.

³ Because some benefits accrue in the delta, the part of it in the watershed above Yazoo City is carried in tabulations as the delta unit. This excludes the Sunflower, Quiver, and other delta streams entering the Yazoo River below Yazoo City.

⁴ The Sardis Reservoir on the Little Tallahatchie River is completed, the Arkabutla Reservoir on the Coldwater River is under construction, and the Enid and New Grenada Reservoirs on the Yocona and Yalobusha Rivers respectively are proposed and their construction is considered a surety.

TABLE 1.—*Area of principal Yazoo River drainage units above Yazoo City*

Drainage unit	Area			
	Including Little Tallahatchie and delta units.		Excluding Little Tallahatchie and delta units.	
	Square miles	Percent	Square miles	Percent
Coldwater.....	1,000	11.2	1,000	19.9
Little Tallahatchie ¹	1,545	17.4		
Yocona.....	560	6.3	560	11.1
Yalobusha.....	1,320	14.8	1,320	26.2
North Bluff.....	873	9.8	873	17.3
South Bluff.....	1,282	14.4	1,282	25.5
Delta ¹	2,320	26.1		
Total.....	8,900	100.0	5,035	100.0

¹ Included to give complete area of watershed above Yazoo City. These areas are not discussed, except as noted, in this report.

GENERAL PHYSICAL FEATURES

This area has a mild, humid climate with long growing seasons varying from 200 to 225 days. Extremes in temperature range from slightly below 0° F. to 100° F. Mean monthly temperatures vary from 42° F. in January to 82° F. in July. Precipitation averages about 52 inches annually and is generally distributed favorably for agricultural purposes, although severe summer droughts are not uncommon. Light snowfall and ground freezing are occasional during winter months but their effects on agriculture or flood problems are negligible.

The watershed is made up of the delta area and the uplands. The uplands are divided into 4 physiographic areas which extend north and south and roughly parallel each other. They are, from west to east, the deep loess, the brown loam, the clay hills, and the flatwoods. Over the watershed, elevations vary from 100 feet mean Gulf level at Yazoo City to about 500 feet on the highest hills in the northeast part.

The deep loess comprises 44 percent of the upland area. Its soils consist of a mantle of wind-transported silt, varying in thickness from 4 to 40 feet, superimposed over clays, sand, and terrace gravels. Topography varies from rugged hills in the southern part to more rolling lands in the north. The natural topography has been altered considerably in many areas by modern erosion and the land is intricately configured with gullies that often have cut through the loess and the loose underlying sands. Although somewhat lacking in organic matter, the soils are naturally fertile and produce good crop yields under proper treatment. They lose much of their ability to absorb water when left barren or disturbed by cultivation, and excessive surface run-off results.

The brown loam area comprises 32 percent of the upland and is similar to the deep loess in many respects. Much of this area has a thin layer of loess, varying from several feet in thickness on the western edge to only a few inches on the east. The topography is rolling to hilly with moderately narrow flood plains and elevations varying only 100 to 200 feet from flood plains to ridges. In the south central part of this area there are outcrops of clays and less fertile soils; topography is more rolling. This section is known locally as the Blackjack Hills. Except in the latter area, the natural soil

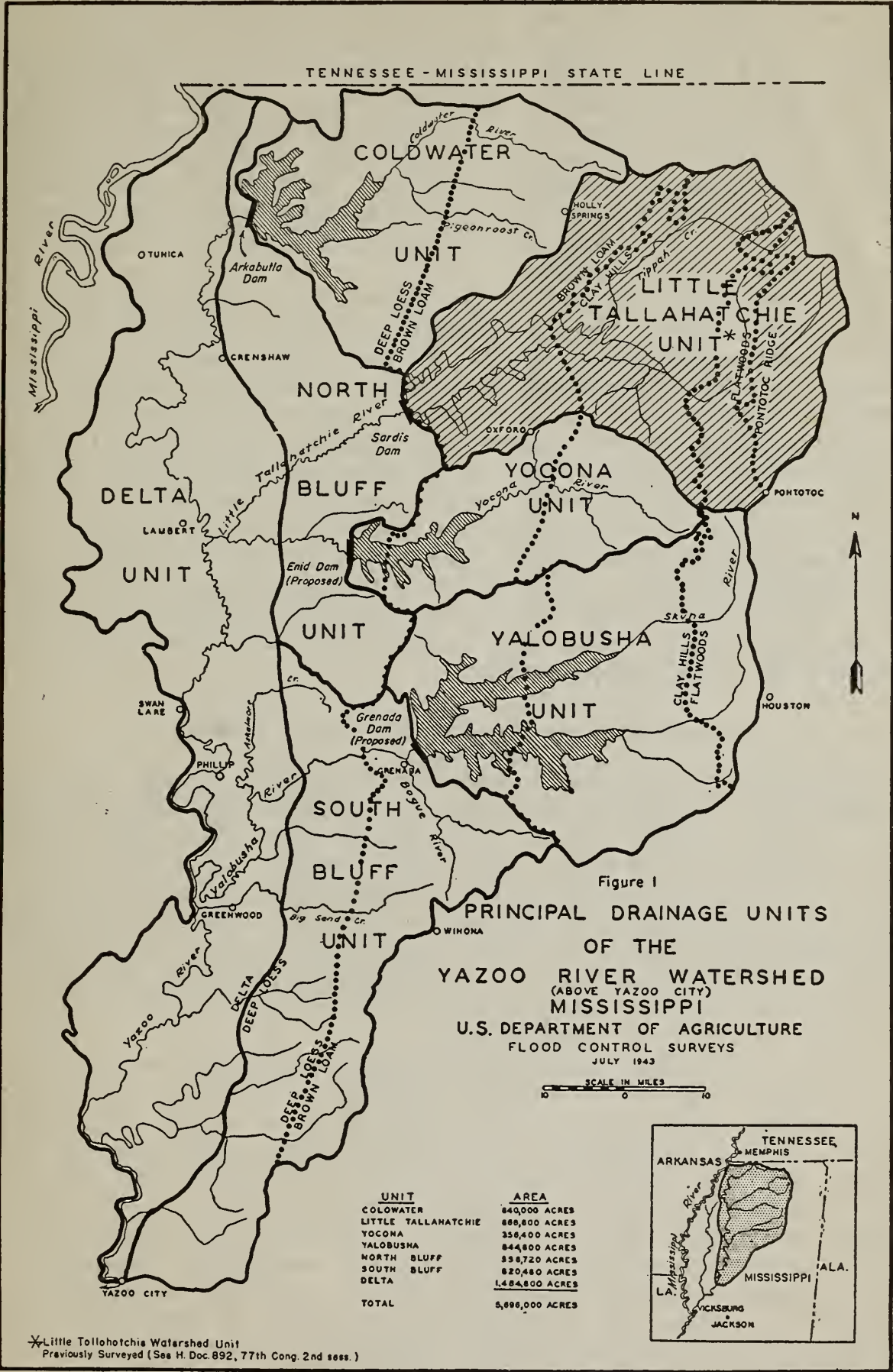


Figure No. 1

is moderately fertile. However, the original fertility of these soils has been largely dissipated through misuse, and erosion has caused destruction and abandonment of extensive areas. The thin layer of loess is quickly lost through sheet and gully erosion, and the underlying sand, which is usually several hundred feet in depth, is flushed in prodigious quantities into drainage systems. Many stream channels in the brown loam are bankfull with sand, and frequently valley bottoms are covered from hill to hill with deposits ranging from a few inches to several feet in depth. This condition is so acute that a number of stream valleys have reverted from cultivation to willow brakes. The brown loam embraces the most severe problems of land use in the watershed.

Approximately 19 percent of the upland area is in the clay hills, an area of low, rugged, wooded hills and soils consisting predominantly of clays with interbedded sands. Stream valleys are narrow at the heads but often form broad flood plains as they converge on main streams. Except for bottom lands and scattered, moderately fertile upland patches, the soils of this area are relatively infertile. Where cultivation has been attempted on the ridges and slopes, it has usually been shortlived and the fields have commonly reverted to forests.

The flatwoods extend into the watershed only in the headwaters of the Yalobusha River and occupy only 5 percent of the uplands. The topography is gently rolling with low relief and broad flat valleys. The soils are principally heavy, impermeable clays; they are only moderately fertile to infertile, but the area is extensively farmed because of favorable topography.

THE LAND—ITS DEVELOPMENT AND CONDITION

The history of the Yazoo watershed is principally one of cotton production. For a time, this type of agriculture brought prosperity to a colonial system of agriculture and the area was widely known for its culture and wealth. As in other sections of the old Cotton Belt, this particular crop has been a prime factor contributing to the economic deterioration of the area. Not only has cotton failed to bring sustained wealth, but it has developed a system of cultivation which has all but exhausted the soil resource, and has imposed a form of economic bondage that impedes the development of a more progressive and diversified agriculture.

White settlers first established residence within the watershed in 1800, and in a short time displaced most of the Choctaw and Chickasaw Indians who were occupying the lands of north Mississippi. About 1825, a permanent white settlement was established at Red Banks, near the northern boundary of the watershed, and by 1836 all the area came under organized county government. In 1834 a Government land office was opened at Pontotoc, and within a few years most of the land passed to private ownership. Settlers and homesteaders acquired most of the land, and land companies the remainder. These early settlers found a region of fertile soils traversed by clear, deep streams and supporting an abundant wildlife in its dense, almost unbroken forests of hardwoods and conifers.

Land was rapidly cleared on the better-drained flood plains and the more level uplands; the pressure for open lands soon led to the clearing of steep slopes and further encroachment into wet lowlands. From the early days of settlement to the middle of the nineteenth century,

a self-sufficing type of agriculture was essential and corn was the most important crop. Cotton was gaining favor, however, and was grown on about one-third the cropland, although small grains and food crops held important places. Cotton soon began to dominate agriculture and by 1930 it occupied half the cultivated acreage. Comparatively recent restrictions imposed by the cotton-reduction program, rather than local wishes, have tended to reduce cotton acreages, although the crop still occupies about one-fourth of all the cropland. The reduction in cotton has been accompanied by an increase in corn acreage rather than more diversified uses, and the continued production of clean-tilled crops on highly erodible soils is further aggravating the flood problems confronting this watershed.

Logging and sawmilling industries began in a small way with the early settlers and have been closely associated with agricultural expansion. However, sawmilling did not play an important part in the economy of the region until the twentieth century. The center of lumbering is now in the southeastern part of the watershed where the last sizable areas of timber are being rapidly liquidated.

Approximately 91 percent of the watershed is in private ownership, about four-fifths of which is in farms and one-fifth in nonfarm ownership. Public land ⁵ amounts to about 7 percent of the area and the remaining 2 percent is in roads, towns, and miscellaneous uses (table 2). Most of the nonfarm land is owned by lumber companies or nonresident owners and is located in the forested sections of the Yalobusha and South Bluff units.

The farm land is in units varying in size from 15 to several hundred acres. An average size farm totals approximately 140 acres, of which only 55 are in cropland. As the tenant and share-crop system is customary, each farm on an average supports almost 2 families and hence the cultivated acreage per family averages only about 28 acres. About three-fourths of the farms are owner-operated; but most of them have tenants on the property.

Forty-one percent of the upland area is in forest and 59 percent is in open land uses (table 3). The 2 main crops are corn and cotton, both clean-tilled and produced on 35 and 27 percent of the cropland, respectively. Thirty-eight percent of the cropland is devoted to hay, legumes, truck, or is lying fallow. Over one-fourth of the entire upland area is in pasture or lying idle.

TABLE 2.—Major land ownership by drainage units

Ownership	Cold-water	Yocona	Yalobusha	North Bluff	South Bluff	Total
Public:	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
National forest.....	640	8,300				8,940
Land utilization project.....		2,048	13,006	5,428		20,482
Private:						
Farm land.....	505,485	241,801	521,381	463,466	632,352	2,364,485
Nonfarm land.....	63,270	59,141	192,387	75,333	166,879	557,010
Other: Roads, towns, etc.....	14,600	7,982	18,635	13,955	20,493	75,665
Subtotal.....	583,995	319,272	745,409	558,182	819,724	3,026,582
Reservoir areas.....	56,005	39,128	99,391	538	756	195,818
Total.....	640,000	358,400	844,800	558,720	820,480	3,222,400

⁵ Of the 7 percent public land, 8,940 acres is in the Holly Springs National Forest, 20,482 acres is in the Coffeeville land utilization project, and 195,800 is in the existing or proposed flood-control reservoirs of the U. S. Engineer Department. The disposition or use of the reservoir areas is indefinite and acreage or percentage figures hereafter used refer to the watershed exclusive of the reservoir areas, roads, towns, etc. The watershed area used hereafter is 2,950,900 acres.

TABLE 3.—*Principal land uses in the watershed*¹

Land use	Area	
	Acres	Percent
Forest.....	1, 205, 016	40.8
Cropland.....	936, 492	31.8
Pasture.....	528, 349	17.9
Perennial cover.....	621	-----
Idle.....	236, 098	8.0
House sites.....	44, 341	1.5
Total.....	2, 950, 917	100.0

¹ Exclusive of 75,665 acres of roads, towns, etc., and 195,818 acres in reservoirs. Total area including these is 3,222,400 acres.

A principal influence contributing to the depletion of plant cover and soil resources is the traditional practice of obtaining the greatest immediate cash return with the least current expenditure of management effort. Almost 40 percent of the farm land is in cultivation, three-fourths of which is in cotton, corn, or lying fallow. About half of the crops are located on upland soils which are subject to severe erosion (pl.1). Legumes, oats, and other cover crops protect only 7 percent of the corn and cotton land during winter months when rainfall is particularly damaging. A quarter of a million acres are idle and unproductive in addition to 100,000 acres of fallow cropland. The idle land generally supports a stand of broomsedge but is burned over repeatedly and dissected by numerous active gullies (pl. 3). Until recent years, no attempts have been made to follow a definite system of crop rotation; cotton and corn generally occupy the better, though rapidly deteriorating soils; and hay crops of lespedeza, soybeans, or cowpeas are planted on the poorer sites. Although contour cultivation is now commonly practiced, only a small portion of the cropland is terraced adequately; ill-designed outlets, in many instances, have actually increased run-off and soil losses.

Less than 20 percent of the pastures have been even partly improved and few are fully productive. In general pastures consist of land unfit for further crop use, that has merely been fenced and grazed (pl. 2). The usual result is a gullied field supporting mainly un-nutritious native grasses and weeds on the uneroded portions. Such a condition leads to overgrazing during most of the year, and serious shortages of forage during dry summer months.

Most of the forests are culled, second-growth stands which have been or are being cut over with little thought for the future. Some stands, particularly in the Yalobusha and South Bluff units, contain substantial volumes of timber, but even here the productive capacity of the land is not being fully utilized. All forest types within the watershed are of commercial importance and are capable of producing appreciable revenue under proper management. Inadequate management, however, has reduced growing stock to a preponderance of small, defective, and poor quality trees (pl. 4). Fires have destroyed ground cover and discouraged reproduction of the more desirable species. Overgrazing is common on nonfarm land as well as in farm woodlots, not only preventing adequate forest reproduction but also compacting the ground and lowering the rate at which rainfall in-

filtrates into the soil. Adequate fire protection and grazing management are confined to the few thousand acres in national forest. Grenada, Chickasaw, and parts of Calhoun County are under State-organized forest-fire protection and here the average annual burn has been reduced to about 3 percent of the area protected. About 90

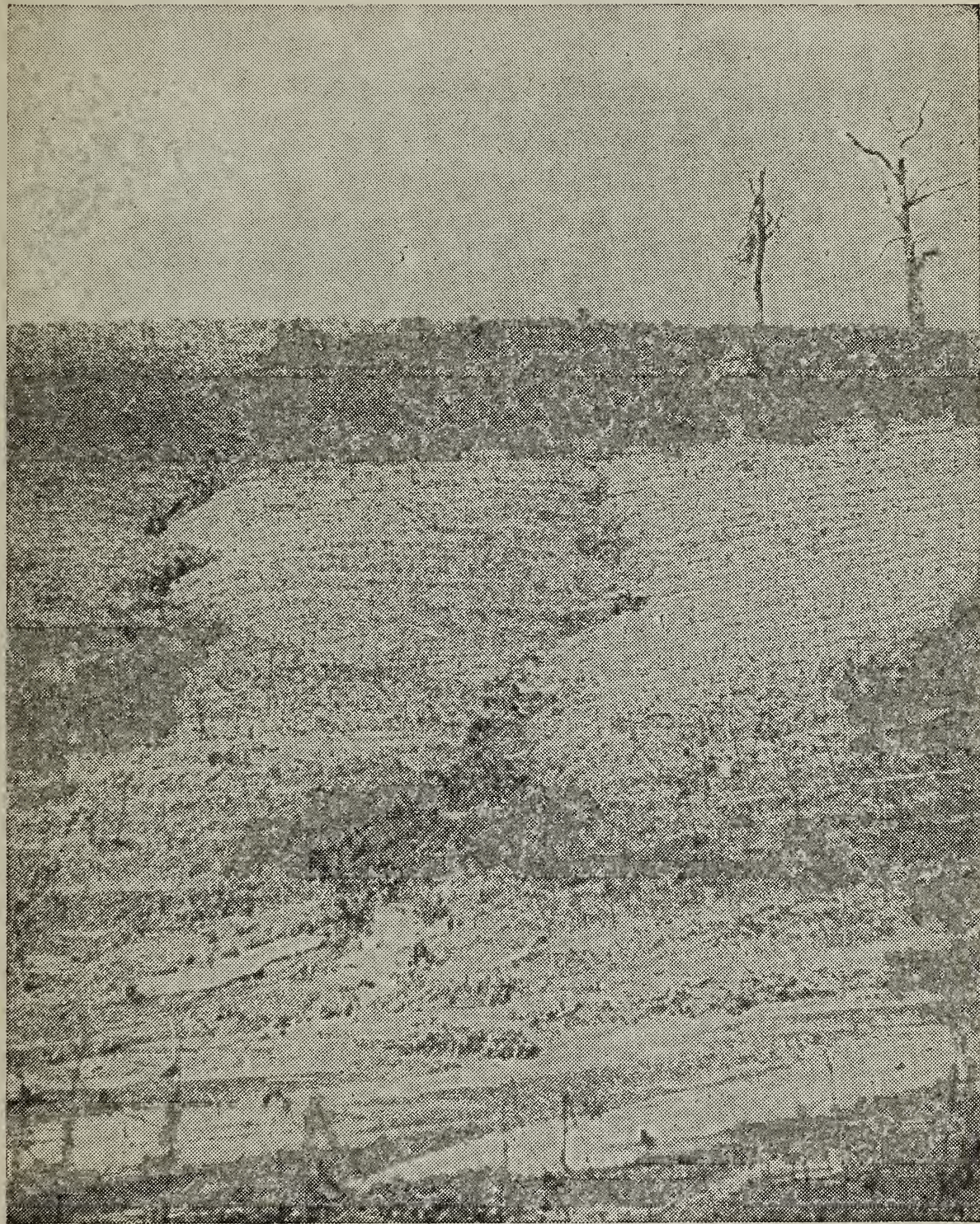


PLATE 1.—Cotton farming—steep slopes—abandonment. This field in Lafayette County has been cleared only 3 years.

percent of the unprotected forested area has burned over in recent years and more than half is burned at least once every 3 to 5 years. Frequent fires have been one of the more important factors in bringing forested lands to their present unsatisfactory condition. When the humus and ground cover are destroyed and the forest floor left

barren and compacted by fire, surface run-off is greatly increased. Annual growth of these forests averages not more than one-third of potential production and at present depletion rates, growth will reach much lower levels. Under present practices the forests of this



PLATE 2.—Many pastures are severely eroded and support a meager grass cover only between gullies.



PLATE 3.—Severely eroded idle land occupies about 10 percent of the watershed.

area are rapidly becoming a liability rather than an asset to the local economy.

Agriculture has long since reached its peak in this watershed. To maintain satisfactory economy the trend in land use must inevitably

be toward conservative soil husbandry on areas still suitable for agriculture and toward the development of sound forestry practices on the land not suited for crop and pasture use. Based on physical characteristics,⁶ 65 percent of the watershed is now not suitable for agriculture (fig. 2). Some of the land not suited for continuous agriculture can, however, be retained in farm ownership, but much of it is so located or is in such poor condition that its continuance as part of farm units would amount to an encumbrance.

THE PEOPLE AND THEIR ECONOMY

Approximately 204,000 persons live in the watershed; 79 percent are rural-farm; 12 percent, village or rural-nonfarm; and 9 percent, urban. Negroes slightly outnumber the whites (table 4).



PLATE 4.—Most forest stands in the watershed are understocked, burned, and severely grazed. Gullies are not uncommon in the forests and surface run-off is severe.

TABLE 4.—Population characteristics in the watershed, 1940

Drainage unit	Total population	Negroes		Rural-farm population		
		Total	Proportion of total	Total	Proportion of total	Density persquare mile
	<i>Number</i>	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>	<i>Number</i>
Coldwater.....	46,755	32,617	69.8	41,821	89.4	41.8
Yocona.....	23,046	7,710	33.5	15,028	65.2	26.8
Yalobusha.....	40,903	12,594	30.8	34,151	83.5	25.9
North Bluff.....	41,428	22,514	54.3	30,338	73.2	34.8
South Bluff.....	51,614	31,841	61.7	39,720	77.0	31.0
Total.....	203,746	107,276	52.7	161,058	79.0	32.0

⁶ Land is classified as generally unsuited for continuous agriculture if slopes exceed 10 percent or erosion is severe with frequent gullies present. Other adverse factors such as soil types, lack of accessibility, and various economic difficulties may tend to increase slightly the area not suited for continuous agriculture.

Only 5 towns, Grenada, Oxford, Water Valley, Lexington, and Holly Springs, may be classed as urban centers, and their populations range from 5,800 to 2,800. There are 32 rural-farm persons per square mile in the watershed, which is comparable to 29.5 for the State. The east central portion of the watershed has the lowest concentration, whereas the greatest density occurs in the northern portion where most of the land has been cleared for agricultural use. In the watershed as a whole, population has remained fairly constant since the beginning of this century, although the fertility ratio indicates rapid growth. This suggests a considerable outward migration accompanying the depletion of land and timber resources.

The 17,023 farms in the watershed now have a gross annual income of \$19,283,000; farm income is gradually declining, attributable in large part to floods and erosion. Twenty-eight percent of gross income is in the form of home-used products; 8 percent is from forest products; 18 percent from livestock; and 46 percent from the sale of crops. Cash operating expenses, exclusive of labor and interest, amount to \$4,996,000 annually. Gross income less expenses and value of home-used products leaves a net cash income of \$8,975,000. Average net cash income on each of the 17,023 farms equals \$527 annually, but when prorated to the 31,036 families amounts to a net cash income of only \$289 per family. Such income imposes a low living standard on the rural people, which in turn is reflected in the economy of the population at large. Having very limited cash resources, the people of this area generally lack the advantages of adequate medical attention, simple sanitary facilities, balanced diets, and essential social privileges and facilities. Insufficient cash income also precludes the purchase of fertilizer necessary for proper rotations and crop development and prevents the installation and maintenance of soil-conserving improvements, thereby further aggravating erosion and flooding problems which foretells lower income in the future.

In 1940, 38 percent of all farms were mortgaged for an average of 42 percent of their total value. Aside from mortgage indebtedness, it is local practice to borrow money from banks or individuals each year to cover crop expenses, repaying the loan each fall with income derived from the sale of crops and produce. This practice results in a cycle of indebtedness that continues to grow more burdensome, especially when crop failures or flood damage upset the balance.

Each year the net amount of good cultivatable land becomes less. Without proper measures to hold the soil, many upland fields erode rapidly and often can be retained in cultivation not more than 5 years. The eroded material is washed onto valley lands and together with augmented run-off greatly increases bottom-land flooding and buries fertile alluvial soils beneath layers of sterile sand. As cotton production requires a large labor supply to till a comparatively small acreage, the decline in land available for crops together with reductions in cotton acreage have now developed a general situation whereby a large dependent population cannot be adequately supported on the available land. With few industrial developments to utilize excess or part-time labor, the result has been smaller incomes per family and a diminishing standard of living.

Over half the farm land is worked by tenants, especially those of the sharecropper class, most of whom move at least once every 5 years. This continual migration tends to maintain unsatisfactory living conditions for a large segment of the population and also encourages

nonowners to exploit the land. Markets for such items as poultry and dairy products are largely located in centers of greater population and the difficulties of marketing special produce have discouraged many farmers from producing these supplementary sources of income. In the Memphis trade area, there has been a marked development of the dairy industry and some other towns have recently become the sites for cheese plants and condenseries. Such developments, however, are of too recent origin to have influenced much the desirable transition from cotton to a more stable economy based on diversification of enterprises and supplying adequate outlets for labor during the entire year.

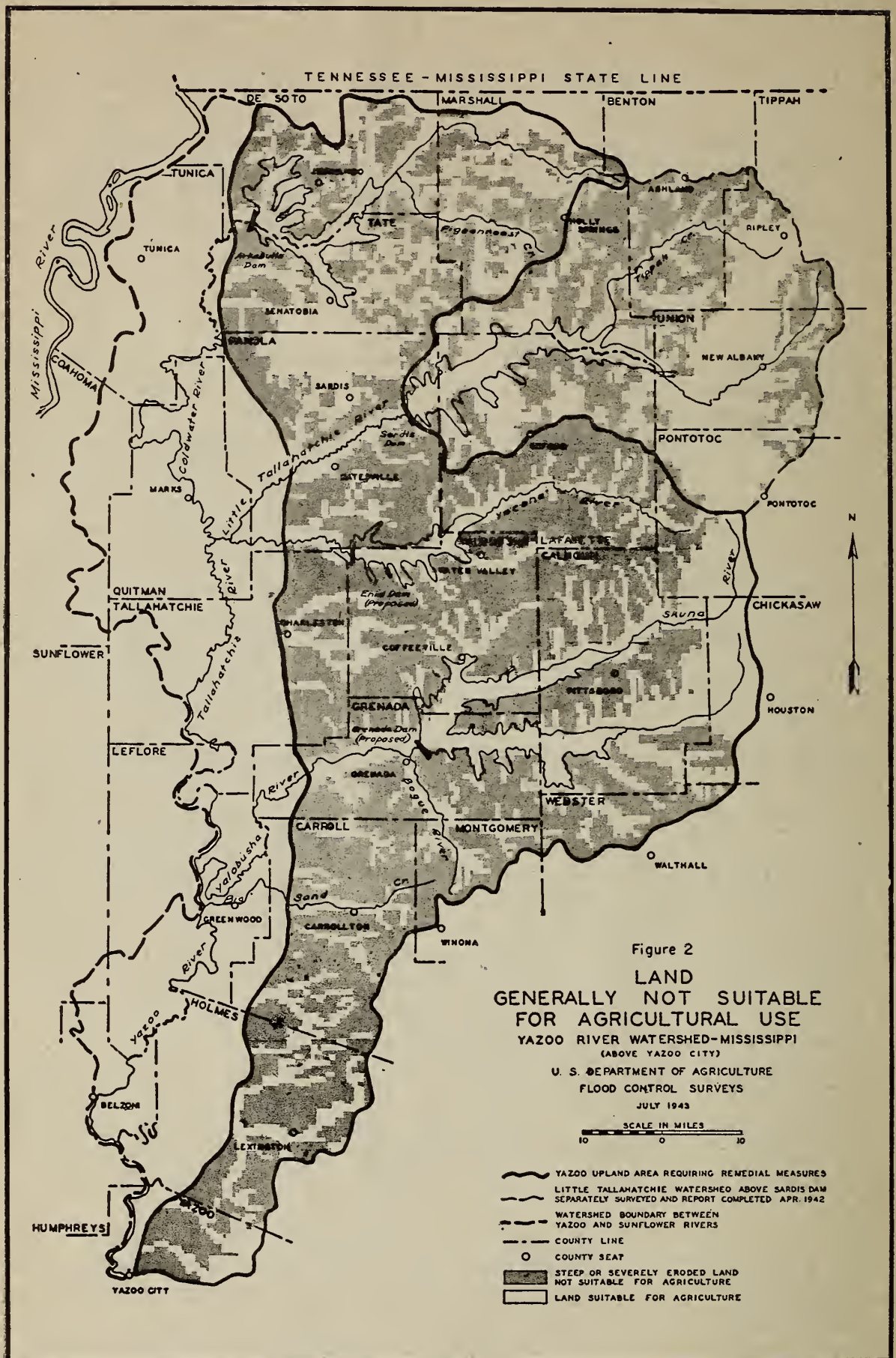
GENERAL ECONOMIC-SOCIAL PROBLEMS

Population, in excess of that which basic resources can sustain on a permanent basis is a major economic and social factor underlying the problems of this watershed. There are practically no industries in the watershed which are not directly associated with the production of crops or timber. In spite of decreasing agricultural opportunities, the population has remained fairly constant in recent decades, hence the pressure on the land has accelerated as its fertility has declined. This pressure will increase when the proposed reservoir program is complete. Relief through the development of other outlets for labor is not at all promising. In recent years there have been some exploratory developments for oil and gas, but there is little evidence indicating important underground resources. Aside from products of the soil, the area appears to have few other major resources which can profitably be developed.

As the soil and timber resources have been exploited, the tax base has decreased. Local governments are faced with the necessity of either increasing assessments or maintaining valuations on lands of decreasing value. This procedure normally results in taxation in excess of the productive capacity of the land and ultimately leads to tax delinquency. Delinquency, however, has not yet developed into a serious problem as revenue from leases based on speculative underground values and Federal conservation payments to landowners have in recent years provided funds for the payment of taxes. If underground resources prove valueless or subsidies are eliminated, a delinquency problem will inevitably develop.

Sickness and disease tend further to depress the area. Although public-health agencies have made considerable progress in preventing and controlling diseases, precautionary measures are not in common use. Low family incomes definitely limit medical attention with the result that death rates are relatively high especially in the younger ages.

Education facilities in the watershed are not adequate. Only about one-third of the people have had limited or formal education. Although improved transportation facilities have made consolidation of rural schools possible and conditions have been bettered in recent years, high-school enrollment lags. Low salaries paid to teachers, especially in Negro schools, and the mistaken opinion of many rural people that only limited education is necessary in farming enterprises, are barriers to educational progress and to the care of the soil resource. A growing need is for more vocational training covering the fields of



agriculture, soil conservation, forestry, and the manual trades. Various land-use agencies have carried on some land-use educational work among owners and operators, but this work has not been on a sufficient scale to reach the vast majority of farm families.

CHAPTER II. THE FLOOD PROBLEM

ORIGIN OF FLOODS

The origin of all floods in the uplands is storm rainfall. All general types of storms common to the region; i. e., tropical hurricanes, thunder storms, and frontal storms, are the source of rainfall causing flood run-off. The rainfall of tropical hurricanes and thunderstorms is usually more intense and occurs generally during the growing season, April to November. Flood damage from these storms is greater in the aggregate than that caused by frontal storms normally which are of longer duration and are characterized by low to medium rainfall intensities. Furthermore, the frontal storms usually occur in the winter or spring seasons when damageable values are relatively low; principally they damage property and lower agricultural yields by delaying planting. Most of the major floods occur when storms of long duration or unusually high intensities blanket extensive portions of the watershed. Thus, in the frontal storm of January 17-23, 1935, on the Coldwater Basin, approximately 12 inches of rain fell, of which 10 inches immediately ran off and caused severe flooding in the bottom lands.

Detailed investigations in the Yazoo Basin show conclusively that the depleted condition of the watershed cover is a major cause of floods, principally because this condition lowers the capacity of the soil mantle to absorb water. The result is an abnormal volume of surface run-off from compacted or nearly impervious surface soils and from eroded subsoils. On the smaller watersheds less than 1 inch of rain has caused damaging floods, partly because the run-off was high and partly because the capacity of the stream channels was inadequate. The stream channels contain sediment and debris which have reduced their capacity to convey water to a rate so low that overbank flows may occur 10 to 15 times a year.

NATURE OF FLOODS

The volume of water causing floods comes from surface run-off. As a result the stream discharges rise rapidly to a crest and descend slightly less rapidly to produce a sharp crested hydrograph. This type of flood is accompanied by severe erosion and later deposition of sediment on the flood plain. Because floods are of this type they can be reduced significantly by measures designed to decrease surface run-off and store the increased infiltrate in the soil reservoir. With increased infiltration, much less erosion will take place.

The flood plains of this basin are wide and flat so that large areas of land are inundated by flows only slightly in excess of bankfull stream capacity. Furthermore the drainage of the flood plains after flooding is slow; prolonged inundation results.

Because all types of storms can cause flooding in this watershed, overflows are not confined to certain seasons but occur throughout

the year. Records reveal that of 305 floods occurring on the Coldwater River from 1929 to 1941, inclusive, 161 floods or 53 percent occurred during late winter or spring whereas fewer and smaller floods occurred in the late summer or fall.

Between 1905 and 1943, several floods of sufficient magnitude to command national interest have occurred throughout the uplands, 14 of which flooded the Yazoo delta.⁷ During this same period there were many times this number of smaller floods, the aggregate damage from which is much greater than that from the major occurrences.

A flood-sequence study⁸ indicates that during the period 1929 to 1941, inclusive, the number of floods on various tributaries ranged from 4 to 24 annually varying with land-use conditions and stream-channel characteristics. A medium-size flood having a frequency of approximately once in 2 years during the growing season is caused by a rainfall of about 4 inches lasting from 2 to 6 days. It inundates approximately 330,000 acres and causes a damage of about \$850,000. Such a flood would cause a maximum discharge of 8,250 cubic feet per second on the main stream of the Yalobusha River at Grenada, whereas the normal flow of water at this point is only about 100 cubic feet per second. An average flood of this magnitude causes damage to more than 20,000 farms thus directly affecting the income of about 65 percent of the population.

DAMAGE FROM FLOODS

Damage from floodwater.

More than three-fourths of the bottom lands in the upland portion of the watershed have been cleared and developed for agriculture. At present, approximately 30 percent is in corn, 20 percent in cotton or other row crops, 8 percent in hay or close-grown crops, 4 percent in pasture, 2 percent idle, and the remaining 36 percent in woods or other uses. Major flood damage to these agricultural interests occurs during the growing season and varies according to the condition of the crop, the duration of flooding, and weather conditions following inundation.

In the early spring, flood damage may occur when there is a forced delay in planting operations or when, as a result of flooding, crops must be replanted (pl. 5). After the crops are growing and well advanced, a flood may cause a complete kill or merely a reduction in yield. During the late fall months, a flood may cause complete loss of harvestable crops or a partial loss depending on the depth and duration of the flood.

The duration of a flood is a most important factor influencing damage. In this watershed floods may last from a few hours to several days. The damage depends on depth of inundation or length of the storm period. Another important factor is the weather which follows receding water. A cool, cloudy period following a flood sometimes permits almost complete recovery of the crop, whereas sunshine associated with warm, clear weather will often scald the plants even though the duration and depth of flooding is of minor character.

⁷ Based on a gage height of 35 feet and over at Greenwood, Miss. This stage has been exceeded in each of the following years: 1911, 1912, 1913, 1917, 1920, 1921, 1922, 1927, 1931, 1932, 1933, 1935, 1937, and 1939.

⁸ Refer to appendix, exhibit E, not printed.

In the Yazoo delta, two types of flooding and damage have been appraised other than those occasioned by Mississippi River backwaters. The greater damage occurs where hill streams enter the delta. Here, a decrease in velocity causes silt-laden waters to drop part of their load thus building up extensive alluvial fans. The other type of overflow occurs along main streams in the delta proper. In the past this has been extremely severe. If the present Army Engineer flood-control program is carried out, complete flood protection will be afforded to all of the delta area except to a few low-lying predominantly wooded sections that will be afforded some degree of protection. Only on those areas where partial protection will be afforded are damages here recognized.⁹

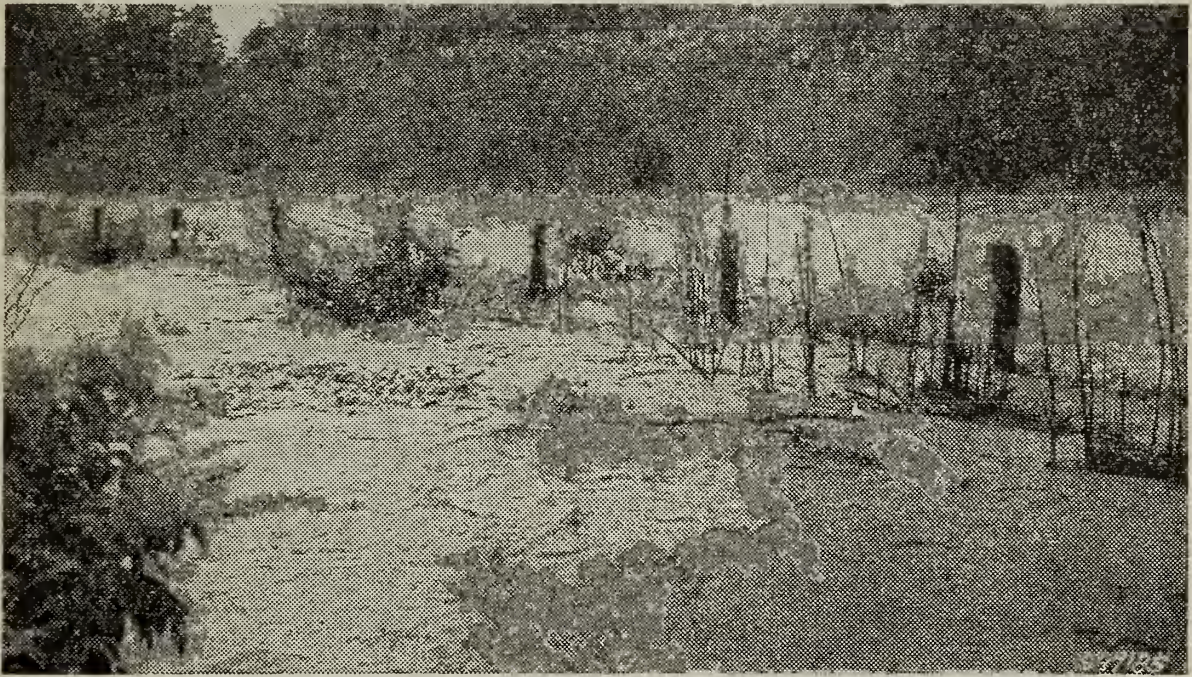


PLATE 5.—A June flood on cotton. This flood was caused by a local thunderstorm and lasted less than an hour. The owner replanted to corn but could expect only low yields.

The agricultural damage (to crops, pasture, and woods) from floodwater originating in the upland portion of the watershed amounts annually to \$1,077,786 in the five upland drainage units, \$461,066 in the alluvial fans, and \$25,616 in the delta main stream areas, a total of \$1,564,468. Approximately 98 percent of the damage is to cotton, corn, and hay (pl. 5). This damage represents a reduction in net income of those depending on agriculture for a livelihood. If agricultural floodwater damages in the hill areas were equally distributed, each family there would suffer an annual loss of approximately \$50.

Flood damage to property in the Yazoo watershed is primarily damage to roads and bridges (pl. 7). Railroads and fences and other farm property sustain a small amount of damage. Very few buildings are located in the flood plain and damage to such structures is usually inconsequential. Occasional losses of livestock are incurred, but farm animals are generally removed from danger areas before flooding.

⁹ Those delta areas that will be afforded only partial flood protection are adjacent to the main streams from Greenwood to Marks.

Damages from the flood of April 8, 1942, illustrate the extent to which overflows damage property values. The precipitation causing this flood varied from $1\frac{1}{2}$ inches in the southern part of the watershed to approximately 8 inches in the northern part. Surface run-off resulted in severe flooding in the Coldwater and North Bluff drainage



PLATE 6.—Floodwater and sediment sometimes cause complete timber kill. Most floods cause some damage to timber.

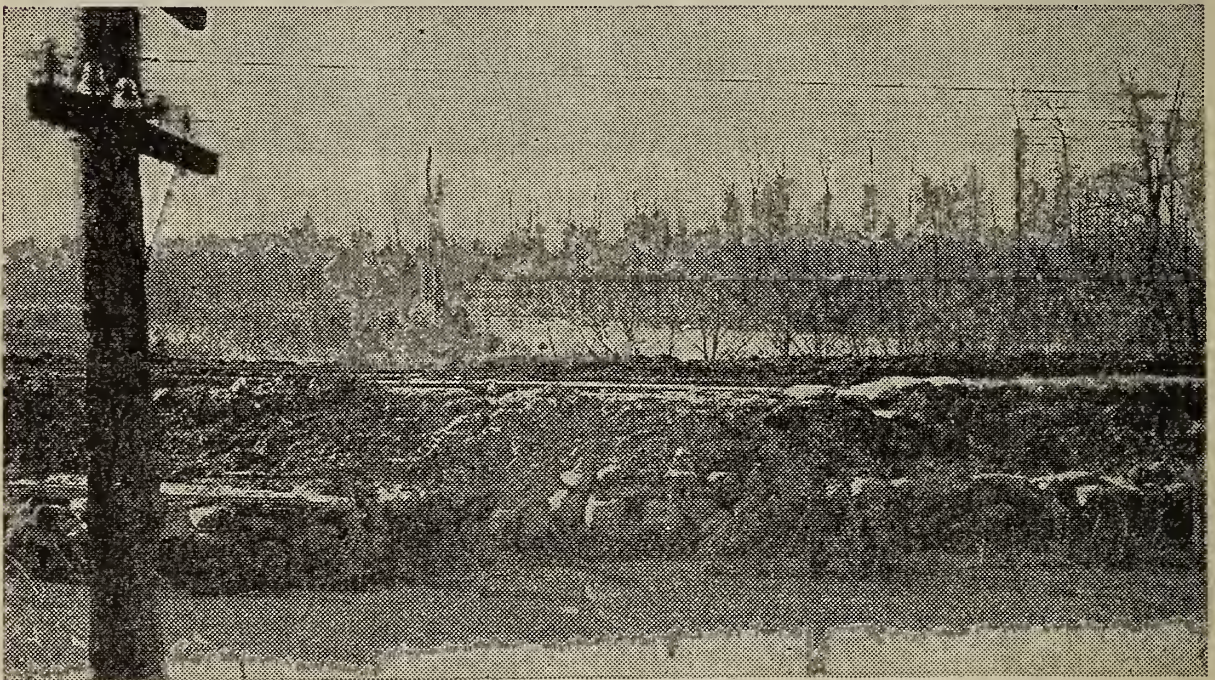


PLATE 7.—Flood damage to Jefferson Davis Highway, near Malone, Miss. Note timber damage in background.

units with somewhat lesser flooding to the south. The measured damages to property alone by this flood amounted to almost \$100,000 of which about three-fourths represented damage to public structures such as roads, bridges, and culverts (table 5).

On the average the annual property damage amounts to \$235,000, of which about 9 percent is railroad damage.

Damage from sedimentation.

Nearly 20 percent of the uplands, or about 633,000 acres, are subject to several types of damage from flood-borne sediment. Sediment from the uplands is also causing damage on 113,000 acres of land in the delta. These cumulative damages are measured by changes in land productivity which are caused by deposition of sediment on flood-plain lands (pl. 8), by swamping of land as a result of deposition which interferes with drainage, and by channel filling which contributes to the overflow (pl. 9). An additional damage is caused by sediment reducing the storage capacity of flood-control reservoirs. Under present watershed conditions, infertile sediment is being flushed into the valleys at a rate of about 89,000,000 tons or 44,000 acre-feet annually. This is increasing.



PLATE 8. Cotton ruined by deposits of infertile sand.

TABLE 5.—Summary of property damages caused by the flood of Apr. 8, 1942¹

Drainage unit	Farm property				Nonfarm property		Public property			Total damages
	Roads, bridges, and culverts	Fences	Buildings	Miscellaneous	Miscellaneous	Total private property	Roads, bridges, and culverts	Miscellaneous	Total	
Coldwater.....	\$1, 400	\$6, 564	\$50	\$7, 744	\$135	\$15, 893	\$34, 112	\$116	\$34, 228	\$50, 121
Little Tallahatchie....	31	157	-----	2, 208	-----	2, 396	10, 472	-----	10, 472	12, 868
Yocona.....	24	179	-----	2	-----	205	4, 269	-----	4, 269	4, 474
Yalobusha.....	19	623	-----	8	-----	650	4, 765	-----	4, 765	5, 415
North Bluff.....	61	2, 717	115	37	3, 510	6, 440	17, 526	60	17, 586	24, 026
South Bluff.....	-----	19	-----	-----	-----	19	2, 570	-----	2, 570	2, 589
Total.....	1, 535	10, 259	165	9, 999	3, 645	25, 603	73, 714	176	73, 890	99, 493

¹ Exclusive of damage to railroads.

Had soils and other watershed resources been properly handled, the net productivity of the 746,000 acres of flood plain subject to damage by sedimentation would now be about \$13.30 per acre annually. Actually, the present net productivity of the average flood-plain acre is only \$5.70, and it will decrease still farther in the future if erosion of the uplands is not checked. The present value of this future damage, expressed as an annual equivalent, amounts to \$737,803 (table 7).

The Engineer Department plans four flood-control reservoirs in the watershed. The Arkabutla (under construction), Enid (proposed), and New Grenada (proposed) are in the area under survey.¹⁰ The sediment transported into these reservoirs under present land-use practices in time will impair their flood-storage capacity to the point where additional expenditures will be necessary for effective operation. Table 6 indicates the extent of this damage.

The average annual value of the damages that will be suffered by reservoirs in the future is \$12,376.¹¹



PLATE 9. A channel completely plugged with sand in Marshall County. Such a condition necessitates frequent re-elevation of railroad fills; it also causes more frequent flooding or even swamping of adjacent flood plains which are lower than the stream channel.

TABLE 6.—*Sedimentation damage to reservoirs*

Reservoir	Approximate period ¹	Capacity loss ²	Estimated total cost of improvement	Average annual damage ³
	<i>Years</i>	<i>Percent</i>		
Arkabutla.....	90	17½	\$2,310,000	\$3,829
Enid.....	100	12½	1,900,000	1,617
New Granada.....	90	17½	4,800,000	6,930
Total.....			9,010,000	12,376

¹ Time at which additional expenditures will be necessary.

² In period of years indicated and point at which structural alterations will be necessary.

³ Annual payment necessary to provide funds for improvement at the time needed.

¹⁰ The fourth, Sardis Reservoir, is completed on the Little Tallahatchie River and is discussed in the Little Tallahatchie Survey Report, H. Doc. 892, 77th Cong., 2d sess.

¹¹ Annual payment necessary to provide funds for improvement at the time needed.

Indirect damage.

Floodwaters and flood-borne sediment cause many indirect damages that cannot be readily appraised. Virtually every flood to some extent interrupts the normal course of business, especially where transportation is disrupted. The farmer loses when a flood delays his operations for several days or weeks; the transportation companies and individual travelers lose time and incur extra costs when highways are inundated or bridges are washed out; merchants and processors lose business when transportation facilities are damaged; and other similar types of losses are experienced throughout the watershed and adjacent area. In the aggregate, these indirect losses may be greater than the direct losses; here they are conservatively estimated to be at least one-fourth the direct losses, or \$637,398.

Damage not evaluated.

In order to appraise flood damages adequately, it would be necessary to determine the effects of floods on human health; on plant and animal life; on business, not only local but country-wide; on both interstate and intrastate transportation; on recreational assets; existing and potential; and on the morale of people who undergo these damages. A loss to farming enterprises affects all associated business and professions and results in lower purchasing power and reduced commerce. Occasional sickness and disease caused by or related to floods requires extra medical expenditures and loss in productive time. Insects associated with flooding weaken and sometimes kill work stock. Frequent flooding prevents recreational development, and especially in areas such as this where recreational opportunities are especially needed to combat frustration brought on by low standards of living. Occasionally floods directly affect fishing and hunting, thereby curtailing important sources of food and desirable forms of recreation. Loss of life by floods, although infrequent in this particular watershed, represents an intangible loss to society which cannot be overlooked. Losses in net incomes affect morale by lowered living standards and the inability of the people to provide such things as educational and church facilities. Although all such intangible damages cannot be measured monetarily, they must be given due weight in analyzing the effect of floods on the watershed economy.

Summary of damages.

In the Yazoo watershed the computed damages amount to \$3,186,988 annually, of which 56 percent is caused by floodwater, 24 percent by sediment, and 20 percent represents the indirect effects of both floodwater and sedimentation (table 7).

TABLE 7.—*Summary of average annual flood damages, Yazoo watershed*

Type of damage	Cold-water	Yocona	Yalo-busha	North Bluff	South Bluff	Delta ¹	Basin total
Floodwater: ²							
Agricultural.....	\$216,544	\$158,591	\$511,370	\$78,375	\$112,906	\$486,682	\$1,564,468
Property ²	55,185	21,397	56,459	44,056	53,737	4,109	234,943
Total floodwater.....	271,729	179,988	567,829	122,431	166,643	490,791	1,799,411
Sedimentation:							
Reduced flood-plain productivity ³	129,599	48,130	109,673	146,278	188,700	115,423	737,803
Siltation of reservoirs.....	3,829	1,617	6,930	-----	-----	-----	12,376
Total sedimentation.....	133,428	49,747	116,603	146,278	188,700	115,423	750,179
All direct damages.....	405,157	229,735	684,432	268,709	355,343	606,214	2,549,590
Indirect damages.....	101,289	57,434	171,108	67,177	88,836	151,554	637,398
Total (all damages).....	506,446	287,169	855,540	335,886	444,179	757,768	3,186,988

¹ Damage attributable to run-off from the upland areas.

² Damage to agricultural property is included with "property" rather than with "agricultural."

³ Based on anticipated future decline in productivity, assuming productivity declines for 200 years and then stabilizes at that level.

CHAPTER III. THE REMEDIAL PROGRAM

The analysis of flood problems and their causes, as outlined in the preceding chapter, clearly indicates the need for a comprehensive program of land treatments in aid of flood control in most of the Yazoo River watershed, exclusive of the Delta unit. The same program is required no less urgently in order to stabilize and restore an agricultural economy which will dwindle to still more meager levels of living unless exploitative practices are corrected.

In developing a land program in aid of flood control, the general objective is to reduce run-off and erosion to a practical minimum by improving the cover on all nonarable lands and by adopting methods of tillage and land management which furnish optimum protection to croplands. However, these general aims must take into account the practical limitations of converting all lands to a use or condition affording maximum restraints to waterflow. In this particular area, economic considerations dictate that as much land as possible be utilized for agriculture. As treatment for flood-control purposes entails rather drastic changes in cropping practices, remedial plans must be worked out for individual farm holdings and insofar as possible adapted to the economic needs and financial means of the owner.

Few if any landowners in this area can entirely finance the cost of such a flood-control program. Some public assistance is therefore prerequisite to achieving any large-scale treatment of farm lands, including those generally well suited to sustained production under present ownership. On the other hand, thousands of acres are too impoverished to be rehabilitated under any practical plan of farm management. For these areas, public ownership and treatment afford the only practical solution.

In line with these guiding principles, a comprehensive, unified, land-improvement program has been developed for the Yazoo Basin. Although the primary purpose of this plan of action is to prevent or alleviate flood damages on valley lands not protected by existing or proposed works of the United States Engineer Department, the measures will function just as effectively in conserving water and soil

in place and utilizing these basic resources for productive purposes. The program is applicable to the watershed lands of the Coldwater, Yocona, Yalobusha, and Bluff units, exclusive of the land in reservoirs. It represents the most effective combination of measures for flood-control purposes that can be developed in accordance with available facts and the practical considerations which limit ability of landowners to participate in the prescribed work. The program involves (1) treating cultivatable lands to conserve soil and water; (2) decreasing flood run-off from pasture lands by improving vegetation and building up the soil; (3) restoring and extending forest cover through a fire-control program and the reforestation of open and severely eroded areas, and timber management; and (4) controlling erosion along public highways.

With few exceptions, the measures prescribed for flood control are similar to those currently undertaken in the Yazoo area as a part of agricultural and conservation programs of the Department of Agriculture and the States.¹² None of the work of the several agencies is basin-wide in extent or on a sufficient scale to afford the degree of protection to soil and cover that will be necessary if the flood damages are to be lessened materially.

IMPLEMENTING MEASURES

A cooperative land-improvement program involving large-scale public assistance requires organized facilities for carrying out the measures and insuring that the public's investment will be safeguarded through adequate maintenance and continuity of effort. Treatment of the more productive lands that are suited to long-range private ownership will logically channel through legally constituted, local agencies, such as the soil-conservation districts. Treatment of the more severely eroded and unproductive lands, which contribute disproportionately to flooding of bottom lands and are a major economic problem, must necessarily be contingent on efforts to stabilize or establish some reasonably permanent form of ownership; to a considerable extent, the latter objective can be realized only through outright purchase and treatment of much of the land at public expense.

Utilization of soil-conservation districts.

Ten counties, wholly or partly within the area for which a flood-control program has been formulated, have already organized soil-conservation districts and are carrying on a soil-saving program on the farms of more than 900 cooperators. Technical assistance is provided through the personnel and facilities of the Soil Conservation Service. As piecemeal treatment of lands is inadvisable, the organization of new districts in the remaining 5 counties is essential and must be accomplished before an action program in aid of flood control can be undertaken on a basin-wide scale.

When the proposed program is fully implemented through the formation of these organizations, measures applicable to farm lands can be carried out effectively on a voluntary, cooperative basis on the greater part of the land now in farm ownership. Studies of the productive capacity, yearly income, and financial needs of representative farms reveal that 57 percent of these will be financially able to install and

¹² Appendix, exhibit F, not printed.

maintain the measures assuming public assistance and a division of costs as prescribed in the program.¹³ Results of this inquiry, adjusted in the light of local experience, indicate that owners of 67 percent of the farm land, or more than 1½ million acres, will voluntarily cooperate in the program. Locally, participation will vary from an estimated low of 25 percent of the farm land in the more impoverished areas of Clay Hills, to 90 percent in the more productive portions of all physiographic areas.

Public land acquisition.

A careful study of the condition and productive capabilities of all lands in the Yazoo watershed shows that about 730,000 acres are too badly deteriorated or will produce too meager returns in the immediate future to justify or permit their rehabilitation at private expense. These areas include 56,000 acres of idle, abandoned lands virtually ruined by erosion and permanently eliminated from further agricultural use (pls. 10, 11); about 441,000 acres of severely burned and depleted woodlands; and 233,000 acres of eroded and worn-out crop and pasture lands largely on prohibitively steep slopes.

These lands are widely distributed throughout most of the Yazoo uplands, occurring predominantly within areas classed as unsuited to agricultural use (fig. 2). About 422,000 acres, or nearly 60 percent of the total, is now owned by farmers having too limited resources to undertake the required improvements or to maintain them once installed. Representative farms with land in this general category have a net cash income from farming enterprises averaging only \$130 per year. This sum is insufficient to meet minimum cash requirements averaging about \$225 per family, let alone defray the farmer's share of first-year costs of installing the farm program which will average about \$17 per unit. The problem cannot be dealt with realistically through increased public subsidies as the depleted condition of this land and the insecure tenure of the occupants will prevent adequate maintenance needed to obtain the anticipated flood-control benefits.

Over 300,000 acres of these submarginal lands are presently in nonfarm ownership without any regular care or management. As on similar tracts in farm ownership, the only possibility of improving the plant cover hinges on these lands being purchased by public agencies, treated according to productive capabilities and needs, and subsequently managed during the period required to restore them to productivity. No program of watershed treatments that excludes such extensive areas of critically eroded, worn-out lands will provide protection from floods and sedimentation. To a considerable extent, treatment of lands unsuited to continued private ownership affords the main opportunity for bringing about marked diminution of flooding and relief from harmful sedimentation to which these lands are a major contributor.

¹³ These studies primarily relate to the financial ability of landowners to incur added costs and temporarily reduced income as a result of necessary land-use conversions during the first few years of the program.

Table 8 and figure 3 show the location, extent, and cost of acquiring lands recommended for public ownership in aid of flood control. This area of 730,000 acres represents 31 percent of the net land area susceptible to treatment. The lands are located in all units except the



PLATE 10.—No sooner are fields abandoned (background) than the ax is wielded to clear new steep land—perpetuating a cycle of declining economy.



PLATE 11.—With most of their farm land gone, some farmers cannot continue the fight against increasingly lower standards of living.

delta. Cost of land purchase will average about \$9 per acre including the appraisal value of timber and improvements, the cost of examination surveys and title clearance, and general overhead expenses. The estimated total cost is about \$6,500,000.

TABLE 8.—*Extent and cost of acquiring critically eroded or unproductive lands requiring treatment at public expense in aid of flood control*

Drainage unit	Area now in public ownership	Area rec- ommended for pur- chase	Proposed future area in public ownership	Cost of acquisition	
				Per acre	Total
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>		
Coldwater.....	640	70, 561	71, 201	\$8. 27	\$583, 333
Yocona.....	10, 348	107, 277	117, 625	8. 15	874, 327
Yalobusha.....	13, 006	187, 994	201, 000	9. 16	1, 721, 225
North Bluff.....	5, 428	83, 092	88, 520	8. 80	731, 239
South Bluff.....		280, 917	280, 917	9. 38	2, 635, 526
Total.....	29, 422	729, 841	759, 263	8. 97	6, 545, 650

This purchase program can be completed within the 20-year period as scheduled in this plan, and most of it consummated in much less time if desired. It should be launched at the beginning or preferably in advance of specific flood-control operations, as important measures cannot be undertaken on much of the watershed until these lands come under public ownership.

Purchase of submarginal lands under this program will be predicated on a system of voluntary sales. In no instance will owners be forced to sell holdings under threat of condemnation. Progress of acquisition programs in contiguous areas ¹⁴ shows that land of this character can be acquired readily, the majority of owners preferring to be relieved of the expense of holding nonprofitable lands.

The area of farm land to be purchased represents the aggregate holdings of approximately 5,260 farm families. The number of families requiring resettlement elsewhere will probably be somewhat fewer than this, as some may be in a position to continue farming operations on their land after selling the unproductive portions. Purchase of the land over a 20-year period will require the annual removal to other lands or occupations of about 250 families. In view of the rate at which land is currently being forced out of production because of soil depletion and flooding, some of the rural population will be forced in any event to seek a livelihood elsewhere, even though no lands are purchased by public agencies during the next several decades.

However, definite forms of public assistance will be necessary for about two-thirds of the farm families involved or about 3,500 family units in all. Assistance to such families needing aid in order that they may be so located as not to create other additional land and population problems, will cost about \$800 per family unit, of which \$750 will be direct assistance and \$50 the administrative costs. This part of the program will cost \$2,800,000. In the relocation of these people the possibilities of reclamation projects in the Mississippi Delta must not be overlooked.

Purchase of land in aid of flood control may be accomplished as an augmented phase of existing Federal programs or in fulfillment of acquisition plans which the State, counties, or other local governmental units may wish to undertake. As these lands are to be purchased primarily with a view to applying needed flood-control treatments, the acquiring agency must be in a position to participate in carrying out measures or in maintaining improvements and managing

Notably the national forest purchase program in the Little Tallahatchie watershed.

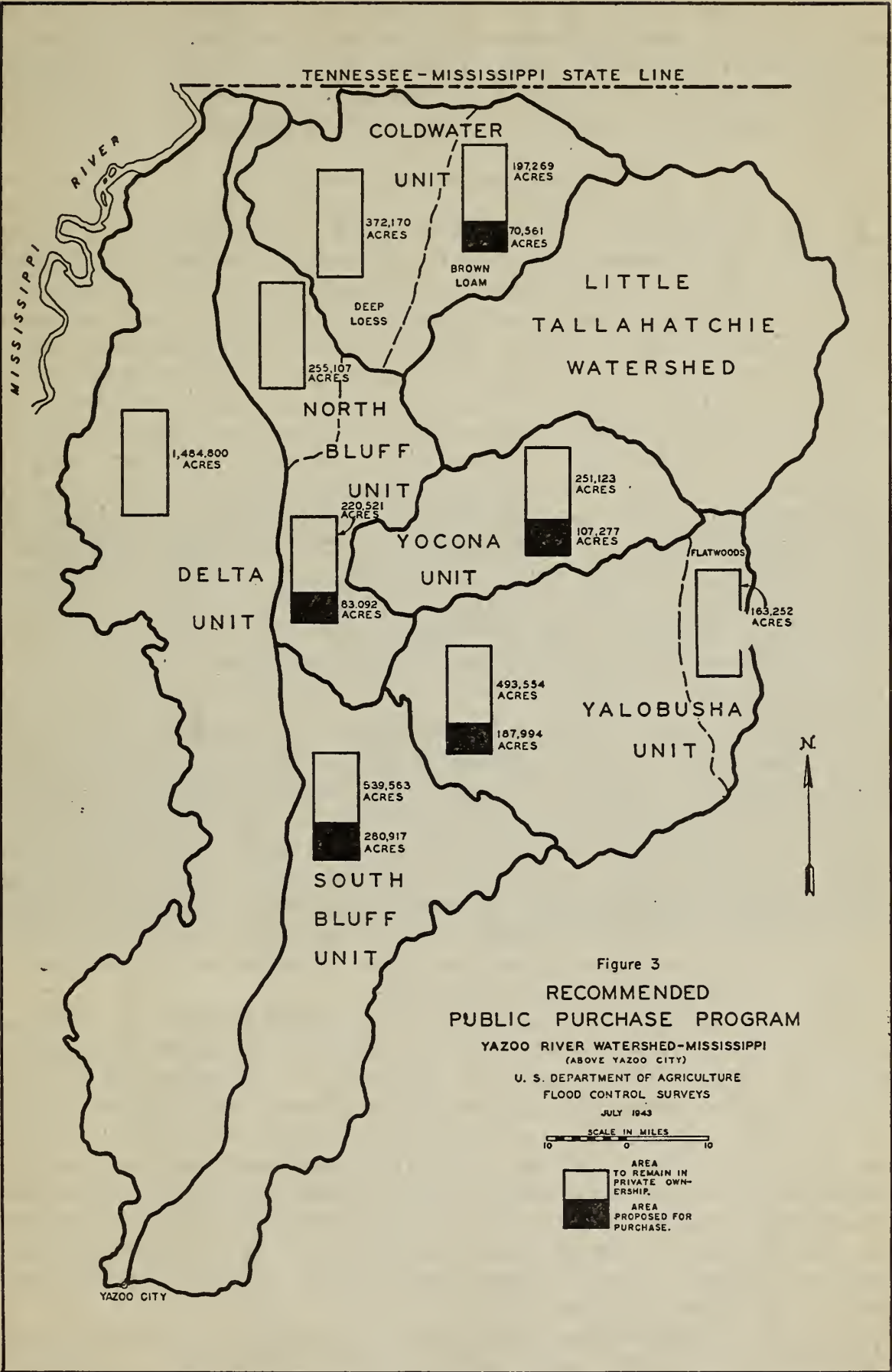


FIGURE NO. 3

Figure No. 3

the lands thereafter. In the main, these lands can be devoted only to extensive uses such as forestry, game and wildlife management, and forage production, and to a limited extent for recreational purposes. Future developments will determine largely the division of responsibilities between public agencies in accordance with specific types of management required and the ability or willingness of State and local agencies to assume a share of the program.

MEASURES ON OPEN LANDS

In the Coldwater, Yocona, Yalobusha, and Bluff units, about 1,177,000 ¹⁵ acres are suitable for the production of cultivated crops, hay, pasturage, and other agricultural products and can be converted to or maintained in such uses indefinitely if treated and managed conservatively. More than 1,000,000 acres or 90 percent of these lands are sufficiently productive to be managed as a part of operating farms in private ownership. The remainder, or about 115,000 acres, will be in public ownership ultimately, as these represent small, intermingled or isolated tracts of relatively good land which will be purchased as a part of larger transactions involving acquisition of worn-out, nonproductive areas. Lands of this character will receive treatment according to needs and capabilities and will be leased subsequently under provisions that insure proper use of these lands for agriculture. Measures recommended for croplands and pastures apply to all such lands whether they are operated under farm ownership or purchased and treated by public agencies and leased to farmers.

Cropland measures.

The recommended measures are designed to reduce soil and water losses through improved methods of tillage, crop rotation, and soil-building practices; the use of terraces and diversion ditches to provide safe disposal of excess drainage waters; and the establishment of close-growing perennial crops on the critically eroded portions of cultivated fields. A gross area of more than 704,000 acres requires this treatment, of which 628,000 acres are now in cultivation and 76,000 acres are to be shifted from other uses, chiefly pasture, fallow, or idle land. A small acreage of forest land, less than 2,000 acres, is suitable for crop use and will receive such treatment.

The more effective flood-control measures applicable to cultivable lands are those coming under the general class of improved cropping practices. These relate more to methods of managing tilled lands than to specific types of measures requiring separate installations and special maintenance. Measures in this category include such time-tested conservation practices as cultivating land on the contour; substituting, insofar as possible, close-growing crops for clean-tilled cotton and corn through a system of crop rotation which will protect soil throughout most of the year; and stepping up the use of fertilizer and the seeding of legume cover crops, mainly as an adjunct to crop rotation and diversification.

Contour cultivation and the growing of crops in bands or strips which extend at right angles to the slope of the land are common-sense practices which entail no added expense and can be adapted to any cropping plan (pl. 12). Although these are not measures in a

¹⁵ Applies only to such private and public lands as can be treated.

strict sense, they represent sound principles of tillage which are basic to carrying out and maintaining other soil-building practices.

Rotation of crops and related practices afford a principal means of protecting the land during critical winter months and of producing the plant residues which are essential to restoring the infiltration capacity. Although the rotation to be practiced on each farm will vary, the system applicable to most of the Yazoo watershed will require that the principal crops, cotton and corn, be followed every few years with lespedeza or similar soil-improving forage crops; furthermore, that corn be interplanted with summer legumes such as soybeans or cowpeas, and that the cotton and corn land be protected during the winter months with vetch, winter peas, burr clover, or winter oats. Under such management, any given tract will be protected fully by close-growing vegetation about half the time, thus affording regular periods for soil building. During the other half of the rotation, the land will be devoted to open-grown crops but will be



PLATE 12.—Run-off is greatly reduced and erosion controlled in pastures in this condition.

protected by interplantings which will reduce soil and water losses to a minimum. This rotation also will increase greatly the production of supplemental feed for livestock and to some extent reduce the acreage in cotton and corn, although increased yields of the latter will more than offset the reduction in area.

The cost of carrying out improved cropping practices is limited to additional expenditures for seed, fertilizer, and labor over and above the amounts normally used in farm operations. This additional expense will be incurred in establishing winter legumes and other cover crops and in shifting every few years from cotton or corn to lespedeza and other types of forage. The added cash cost of these items, based on analysis of operating expenses of representative farms, will average about \$2.88 per acre or, for the watershed, roughly \$1,630,000.¹⁶ Such costs represent annual expenditures rather than cost of initiating

¹⁶ Unit costs as cited for cropland and pasture improvement measures apply to treatment of private lands. Costs of treating such lands as are acquired for public purposes will average somewhat greater owing to the higher cost of employing force-account labor for treating public lands.

the practices, as allocated in this plan, they are chargeable entirely to private interests.

All croplands except those on the flood plain have some portion with sufficient slopes to require terracing, and the area needing this treatment is identical with that requiring rotations and improved cropping practices. It totals about 269,000 acres, of which 12,000 will be in public ownership. The type of terrace required in this area follows specifications that have been worked out on local soil-conservation projects; namely, a variable gradient structure with adequately protected outlets and designed to dispose safely of the run-off from maximum rainfall intensities having an average expectancy of about once in 10 years. Such terraces can be properly constructed using mules and ordinary farm equipment. They are readily maintained as a part of normal farming operations, requiring perhaps an additional plowing each year, the repair of breaks, and the revegetation of damaged outlets. Costs of installation will total about \$1,303,000 and will average for the private owner \$4.65 per acre, of which \$3.20 represents the cost of labor and mules and the rest chiefly materials. Approximately two-thirds of the total cost (labor and mules) is chargeable properly to the farmer with the public contributing supervision, equipment, and most of the materials. The latter assistance is essential to the installation of adequate terraces and construction of proper outlets and facilities for disposing of waste drainage—a problem entailing certain public responsibilities. Maintenance of the terraces is a responsibility of the landowner amounting to only a nominal sum each year, i. e., the cost of a few man-hours of labor.

Somewhat similar terraces will be needed in certain instances where run-off from other contiguous areas, usually gullied or eroded, must be diverted to some nearby natural drainage way in order to eliminate damage to cropland. These diversion terraces must be constructed ruggedly and designed to afford greater capacity for disposal of run-off than is usually provided by terraces of conventional type. To care for all drainage disposal problems of this nature will require the construction of 382 miles of diversion terraces. The estimated cost is about \$23,000 or \$60 per mile, of which almost 90 percent is for labor and mules. In view of the more costly type of construction required entailing considerable supervision, 70 percent of the cost will be contributed by public agencies, the farmer contribution being limited to furnishing labor and mules.

In order to retain certain fields in cultivation, it will be necessary occasionally to establish some form of perennial vegetation, usually kudzu, sericea lespedeza, or other forage crop, on certain eroding portions of the tract. Usually these situations occur on steeper slopes often in irregular strips along the contour where there is a pronounced change in gradient. As a rule the soil has become too impoverished to support a cultivated crop and these critical areas are shedding run-off over lower-lying slopes in quantities sufficient to cause imminent abandonment of the field. About 54,000 acres require this conversion to perennial hay or forage at a cost totaling \$633,000 and averaging almost \$12 per acre. About 83 percent of the cost, including labor, fertilizer, plant material, and supervision, is suggested as a public contribution inasmuch as treatment of this land contributes importantly to the control of floods; furthermore, on account of low yields and delayed returns to the landowner, this work will not be undertaken to any worth-while extent without public financial support.

The planned private contribution will consist of mule labor for installation and all annual maintenance costs, averaging only about 84 cents per acre.

Measures on pasture land.

The recommended program of pasture improvement will materially reduce run-off and soil erosion. These pasture improvements involve: Contour furrowing and incidental ground preparation, establishing simple erosion-control structures, applying fertilizer, seeding or planting desirable forage species, fencing the improved areas, and mowing one or more times annually to control weeds (pl. 13).

Of the area susceptible to treatment, about 445,000 acres will be developed for pasture, of which 357,000 acres will be in cooperating private ownership and 88,000 acres are a part of areas earmarked for public purchase. About 64 percent or 286,000 acres are currently in



PLATE 13. Cropping methods and management in the interest of flood control, soil conservation, and increased crop yields.

pasture use, 91,000 are in cultivation, 60,000 are idle or nonproducing, and less than 8,000 represent the small acreage of forest land suitable for development into pasture. Much pasture land is worn out and requires conversion to forest; the total area in pasture, as planned for the future, will exceed present pasture acreage by about 14,000 acres. However, the gross productivity of pasture lands will be increased greatly through much more intensive development and through conservative management.

About 323,000 acres will require plowing and disking, in preparation for seeding. These operations will leave the seedbed in a furrowed condition with furrows laid out along the contour to collect and temporarily store the rainfall. Costs will total about \$525,000 and for the private landowner will average \$1.40 per acre, 96 percent of which is chargeable to the landowner, with public funds defraying only supervision costs.

On severely eroded areas within pastures, it will be necessary to construct brush dams or similar erosion-control structures to improve moisture conditions, stabilize soil, and otherwise aid in establishing a protective plant cover. About 12,000 of these structures will be required at a nominal cost averaging 50 cents per unit, of which three-fifths is for labor. The cost is entirely a public charge in deference to the heavy contributions of run-off and sediments from these source areas and the economic obstacles to obtaining effective treatment without subsidy. No particular maintenance is required, as these measures, like the initial ground preparation, are preparatory in character.

About 356,000 acres, or 80 percent of the proposed pasture acreage, needs fertilization at an initial cost of \$1,120,000 and at rates averaging 500 pounds per acre. As a principal item of cost is the cash outlay for fertilizer, accomplishment of this vital measure is highly dependent on public assistance. Eighty-six percent of the total costs of fertilizer application is allocated therefore to public sources of funds, with the public furnishing all fertilizer and a minor amount of overhead supervision, and the landowner, the incidental labor for applying the material. Additional fertilizer, averaging annually about 125 pounds per acre, must be applied to maintain the fertility of pasture soils. This annual maintenance cost will average only 72 cents per acre, including labor, and is chargeable properly to the farmer.

On about 346,000 acres of proposed pasture land, plant cover is of such poor composition and insufficient density as to require seeding and planting the areas to desirable species such as Bermuda grass, Dallis grass, lespedeza, white clover, and other valuable forage plants. Costs of seeding are high, averaging about \$7.50 per acre and representing chiefly a cash outlay for seeds. Total cost of the measure is approximately \$2,612,000. As in the case of fertilizer, the money cost of seed is a major deterrent to enlisting private efforts in pasture improvement and hence 80 percent of the cost, comprising that for seed and supervision, is a proposed public charge. Normally, seeding and planting operations are not recurring items and involve no maintenance cost.

Fencing of pastures to control livestock use is a prerequisite to maintenance of an adequate protective cover. Furthermore, the effectiveness of recommended forest measures is highly contingent on the elimination of grazing in woodlands. This can best be accomplished by confining livestock to improved pasture areas which, under the program, will furnish sufficient carrying capacity for all animal requirements. Fencing is needed on about 407,000 acres. Existing structures are poorly constructed and in most instances will have to be repaired or replaced. Costs per acre average about \$3 and the total cost of fencing amounts to about \$1,269,000. This cost should be about equally divided between public and private sources of funds. Under the proposed division of costs, the public will supply wire and supervision and the cooperator the labor, posts, and other materials. Maintenance costs will average about 32 cents annually and will be borne by the landowner.

Mowing of all pastures at fairly regular intervals, although in the nature of an annual maintenance item, is recommended as a specific measure contributing to the maintenance of desirable forage plants which otherwise would be crowded out by inferior weeds furnishing

much less protection to the soil. The annual cost of the measure is insignificant, averaging only about 9 cents per acre—entirely chargeable to the landowner.

Establishment of the proposed program will require the determination of the specific treatment to be accorded each cooperating farm and forest unit. This will require the services of trained technicians. In addition, actual installation of the measures will also require some supervision and direction by trained technicians. The cost of supplying these services is estimated at \$1.10 per acre of lands in farms that cooperate in the program. The area involved in these farms totals 1,593,274 acres. Continuation of a limited amount of technical assistance following installation of the measures is necessary to assure proper maintenance of these measures. This cost is estimated at \$0.027 per acre of land in the cooperating farms. The cost of this technical planning and supervision will be paid from Federal funds.

MEASURES ON FOREST LAND

Approximately 1,176,000 acres¹⁷ of the watershed should be devoted to forest production. About 45 percent of this gross area or 532,000 acres is in farm ownership of a type financially able to participate in the recommended program. Recommended for public purchase are the remaining 644,000 acres, as they afford no incentive for private development. Of the proposed forest area, 884,000 acres or 75 percent are currently classed as forest lands, 114,000 acres are badly depleted pasture lands, 92,000 acres are idle or waste areas, and the remaining 86,000 acres are submarginal croplands.

The program calls for (1) installation and operation of an effective fire-control system which will furnish essentially complete protection to all woodlands in the Coldwater, Yocona, Yalobusha, and Bluff units; (2) reforestation of open lands allocated to forest use, and the installation of supplemental erosion control measures where needed; and (3) inauguration of timber management measures designed to build and maintain a forest cover which will provide control of run-off and soil protection. These measures are needed on public and private forest lands alike and will vary mainly in the manner in which carried out on the two classes of land. As the forest program deals with lands which are yielding virtually no revenue and are costly and time-consuming to rehabilitate, measures will have to be financed substantially from public funds even on lands of private cooperators who are fully able to participate in other aspects of the farm-land program.

Protection from forest fires.

Of the specific measures proposed in this plan, the establishment of a comprehensive system of forest-fire control is undoubtedly the most effective contribution to flood control from the standpoint of costs and relative influence on run-off. The elimination of forest fires results in increases in the water-absorbing capacity of a given soil. It also aids in establishing a cover on extensive areas which otherwise would continue to be major sources of run-off and sediment. Fire-control measures cost comparatively little and entail the installation of facilities and maintenance of an organization which makes possible the protection of all woodlands, including those in ownerships which

¹⁷ Excluding 311,334 acres in noncooperating ownership.

are unable to cooperate in any other phase of the recommended program. Furthermore, the benefits from fire control extend beyond woodland areas, as the possibilities of fire damage to plant cover and forage on pastures and other intermingled open lands are greatly lessened.

The fire-control plan applicable to this particular watershed is predicated on protecting about 1,548,000 acres of forest lands, including those in reservoir areas and noncooperating ownership. The plan is designed to limit annual burn to not more than one-half of 1 percent of the total area protected.¹⁸ The proposed protective system takes into account and assumes the continued use of existing improvements and facilities, both Federal and State, as well as those planned and recommended for the contiguous Little Tallahatchie watershed above the Sardis Dam.

A conventional system of fire control is proposed for most of the Yazoo watershed exclusive of the delta unit. This will provide the usual presuppression, detection, communication, and transportation facilities; fire-fighting tools and equipment.¹⁹ All improvements such as lookout towers, buildings, roads, telephone lines, and facilitating equipment, will be installed or provided at public expense over a 5-year period and the program will be operated and maintained from public funds during the 20 years when the flood-control program as a whole is being established. The annual costs of protecting these public lands will be financed entirely from public funds; that applicable to private lands will be defrayed from cooperative sources under a Clarke-McNary form of agreement, whereby Federal funds would pay approximately half the cost and the remainder would be contributed by the State or local governmental units and by the landowners.

Somewhat different arrangements are planned in two areas where no future public purchase of lands is involved or where existing operations influence requirements. In the deep loess area of the Coldwater and North Bluff units,²⁰ all land will remain in private ownership and the predominance of open farm lands makes it possible to dispense with the usual detection facilities. Here the cost of fire control will be chiefly that of preventing and suppressing fires and will include salaries of wardens and organized local fire crews and the expense of providing necessary tools and equipment. Costs of organizing crews and providing suppression facilities will be a public charge, as in other areas. Annual costs of protecting all private lands will commence the first year and will be shared by public and private interests under a typical Clarke-McNary agreement, with the State having supervisory responsibility and a substantial part of the funds being contributed from Federal sources. Costs of protecting publicly owned forest land in reservoirs are chargeable entirely to Federal funds. In the other area—the Flatwoods portion of the Yalobusha unit—a State Clarke-McNary program is in operation. As no purchase program is planned in this area, fire protection of the desired intensity can be achieved by expanding present installations at public expense, and continuing operation of the system by the State with Federal funds contributing half the cost and private interests a share of the balance.

¹⁸ With an 0.5 percent annual burn and a 10-year recovery period, about 5 percent of the watershed will be in a burned condition.

¹⁹ Appendix, exhibit B.

²⁰ That portion of the North Bluff area north of the Little Tallahatchie River.

Cost of installing the fire-control program will total \$257,000 and will range from about \$24,000 in the Coldwater unit, where comparatively few detection facilities are required, to about \$96,000 in the South Bluff unit where there are no existing facilities (table 9). Costs per forest acre range from about 10 cents to 21 cents, averaging 17 cents for all units. Annual cost of maintenance and operation will total \$94,000, averaging about 6 cents per acre.

TABLE 9.—Cost of installing and operating a forest fire-protection system in the watershed

Drainage unit	Forest area to be protected ¹	Cost of additional installations		Annual maintenance and operation costs	
		Per acre	Total	Per acre	Total
	<i>Acres</i>				
Coldwater.....	236, 212	\$0.10	\$23, 510	\$0.04	\$9, 006
Yocona.....	200, 718	.17	33, 853	.06	12, 101
Yalobusha.....	441, 412	.17	76, 277	.07	30, 899
North Bluff.....	219, 483	.12	26, 947	.05	10, 516
South Bluff.....	450, 436	.21	96, 332	.07	31, 530
Total.....	1, 548, 261	.17	256, 919	.06	94, 052

¹ Includes forest land in reservoir areas and that in noncooperating private ownership.

Reforestation of open lands.

Approximately 292,000 acres of worn-out farm lands, submarginal for any agricultural use, are suitable only for forest production and are to be reforested. About 109,000 acres or 37 percent of the total are included in operating farms capable of participating in the program (table 10). The balance, or 183,000 acres is scheduled for public purchase, as it represents the more impoverished lands that are included in poorly paying farm enterprises which cannot be maintained profitably. Few open lands requiring conversion to forest are producing any appreciable revenue. An extensive portion is so damaged by gulying and sheet erosion that it is ruined permanently for agriculture and can be restored to productive forest use only at considerable cost.

TABLE 10.—Proposed ownership of open lands requiring conversion to forest

Drainage unit	Total area, acres	Private		Public	
		Acres	Percent	Acres	Percent
Coldwater.....	57, 041	27, 525	48	29, 516	52
Yocona.....	37, 906	8, 731	23	29, 175	77
Yalobusha.....	49, 493	9, 404	19	40, 089	81
North Bluff.....	53, 440	29, 189	55	24, 251	45
South Bluff.....	94, 028	34, 521	37	59, 507	63
Total.....	291, 908	109, 370	37	182, 538	63

About 122,000 acres have sufficient seed trees to permit natural reforestation within a few years (table 11). Natural reseeding of open fields can be relied on to a greater extent in the Yocona, Yalobusha, and South Bluff units where pines are predominant, and to a lesser extent on the more open lands of the Coldwater and North Bluff

units where hardwoods are the principal native species. Areas where seed trees are insufficient or are of an unsuitable kind must be planted (pl. 14). In all, about 170,000 acres must be planted, of which more than 47,000 acres are gullied or actively eroding and will require in addition special planting techniques and the installation of erosion-control measures. The latter includes simple soil-collecting dams or trenches, the diversion of run-off upslope from gullies, and other comparable devices to stabilize soils temporarily and aid in establishing the tree plantings.



PLATE 14.—A formerly abandoned gullied field in Marshall County that has been planted to pine. Beneficial effects are already evident even though the planting is only 3 years old.

TABLE 11.—*Extent of open lands to be reforested and cost of measures*

Drainage unit	Land to reseed naturally	Land requiring only tree planting	Eroded land requiring tree planting and special measures	Total	Cost, total
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	
Coldwater.....	18,837	27,307	10,897	57,041	\$478,505
Yocona.....	21,111	12,127	4,668	37,906	209,805
Yalobusha.....	38,609	8,029	2,855	49,493	133,272
North Bluff.....	10,797	30,066	12,577	53,440	536,031
South Bluff.....	32,754	45,129	16,145	94,028	755,992
Total.....	122,108	122,658	47,142	291,908	2,113,605

Costs of reforesting open lands, including replacements and erosion-control measures where needed, average \$12.45 per acre,²¹ and total \$2,113,605. Reforestation costs are chargeable largely to public funds, as the heavy expense and nature of the returns preclude treatment of these critical flood and silt source areas as a private enterprise. Although reforestation costs are here allocated entirely to public sources, in carrying out the work private participation in supplying

²¹ Cost of reforesting uneroding lands averages \$10.35 per acre. Cost of treating and planting severely eroding lands ranges from \$14 to \$23 per acre for the area actually gullied and averages about \$18.

labor, materials, and other facilities not requiring a cash outlay is expected. The amount of private participation will vary with individual circumstances.

Timber management.

Effective fire control and reforestation will fall considerably short of achieving the requisite alleviation of flood damage unless supplemented by definite action to maintain the forest. Unless forest lands in private ownership are maintained properly, it is expected that they will be converted ultimately into other uses for which they are not suited, with consequent impairment of watershed values. Infiltration tests show that the capacity of forest soils to absorb rainfall is correlated with stand density and the optimum infiltration takes place in well-stocked stands (pl. 15).

To achieve desirable practice, it will be necessary to provide cooperators with adequate technical services. This service can be provided most effectively through technicians functioning through the soil-conservation districts.

Annual cost of providing management to the 532,000 acres of private woodlands will average about 15 cents per acre. The cost of administration and management to be given the 644,000 acres of forest lands to be publicly acquired for flood-control purposes will average about 8 cents per acre. Such recurring costs will increase progressively during the 20 years the program is being installed but will level off thereafter.

Public cost of managing the 1,176,000 acres of forest land will total about \$131,000, of which about \$80,000 applies to private woodlands and \$51,000 to the public forests.

TABLE 12.—*Annual cost of timber-management measures on public and private forest lands participating in the program*

Drainage unit	Public forests		Private forests		All forest lands ¹	
	Area	Annual cost	Area	Annual cost	Area	Annual cost
	<i>Acres</i>		<i>Acres</i>		<i>Acres</i>	
Coldwater.....	55,342	\$4,427	107,941	\$16,191	163,283	\$20,618
Yocona.....	104,568	8,366	57,355	8,603	161,923	16,969
Yalobusha.....	187,674	15,014	129,272	19,391	316,946	34,405
North Bluff.....	65,793	5,263	97,646	14,647	163,439	19,910
South Bluff.....	230,837	18,467	139,447	20,917	370,284	39,384
Total.....	644,214	51,537	531,661	79,749	1,175,875	131,286

¹ Omits 311,334 acres of farm woodland in noncooperating ownership.

PLANNING COSTS

The purchase and treatment of submarginal land will require planning and supervision of treatment by various technicians. The cost of such planning and supervision of installation, which will be paid from Federal funds, is estimated at \$1.10 per acre of land purchased. The expanded work load on the administrative force of the Federal agency responsible for purchase and treatment of this land will result in an additional annual administrative cost of 10 cents per acre following completion of installation.

CONTROL OF ROAD EROSION

Controlling erosion on public roads is an important problem. Measurements in this area indicate that 7 percent of the total quantity of modern sediment that has accumulated to date on flood plains had

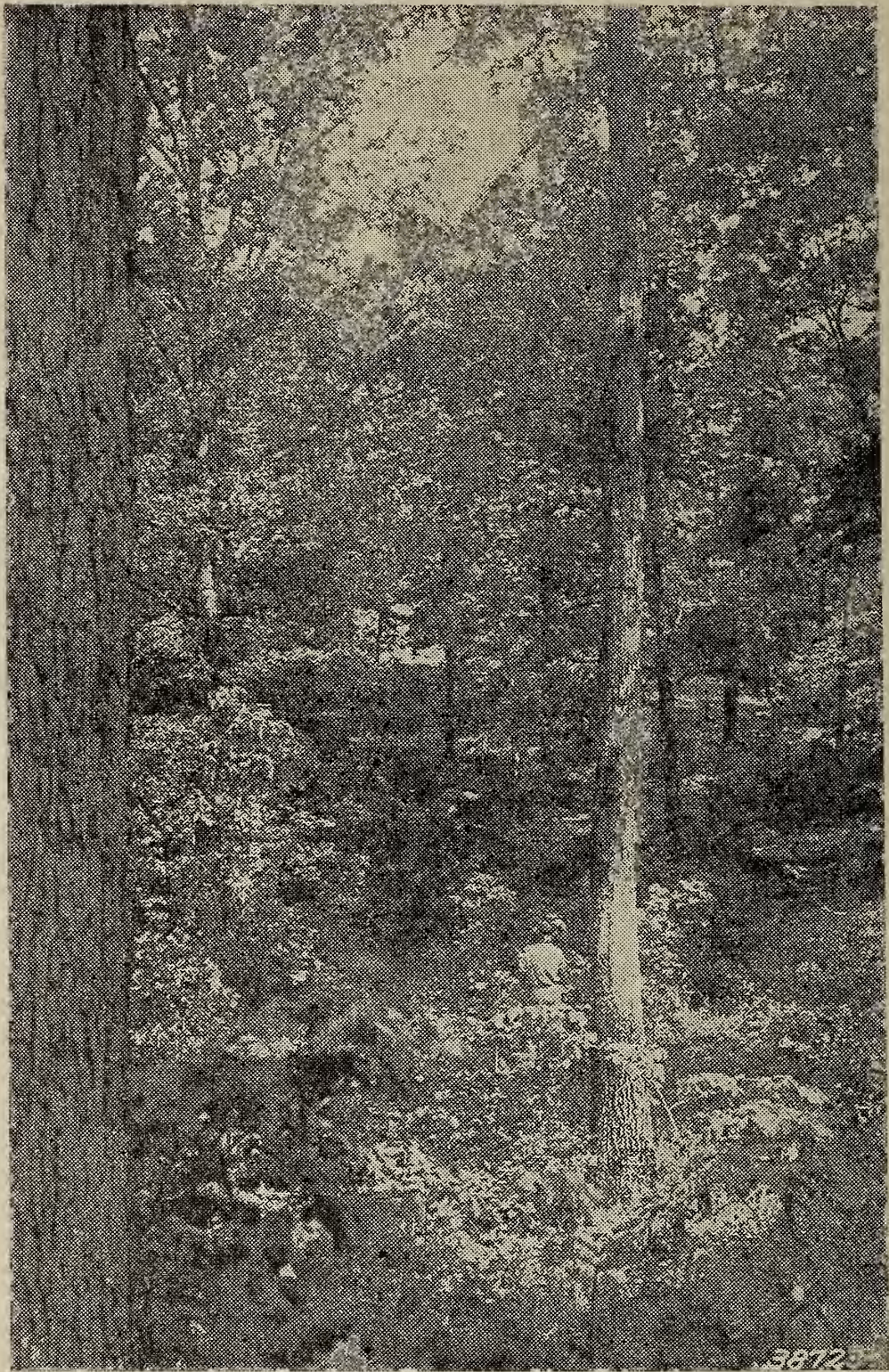


PLATE 15.—A white oak upland hardwood stand in Marshall County. Fire protection and forest management will restore forest stands to a condition of producing income rather than flood run-off.

its origin in soil losses from roads (pl. 16). Erosion also increases costs of road upkeep because of the continual need for maintenance.

Although most Federal-aid highways are currently receiving erosion-control treatments as a practical means of reducing maintenance costs, the greater part of the public roads, especially those

maintained by the counties, are without adequate protection. Omitting uneroding highways which traverse comparatively level areas such as flood plains and the flatwoods area, there are approximately 4,950 miles of public roads in the Coldwater, Yocona, Yalobusha, and Bluff units which are urgently in need of stabilization measures.²² These include 1,517 miles of graded, drained, and surfaced roads and 3,433 miles of unsurfaced roads of lower construction standards.



PLATE 16.—Present eroded road banks contribute enormous quantities of soil to stream systems and are a constant source of costs to local and State governments.

Treatment will consist mainly of establishing suitable vegetal cover on all raw back slopes, fill embankments, and road berms, and stabilizing roadside and lead-out ditches with vegetation and supplemental structures. Highly effective techniques have been developed locally for controlling this type of erosion and the on-site value of this work fully justifies its being undertaken in the interests of reducing maintenance costs (pl. 17). However, these measures are relatively costly and will not be accomplished readily without special assistance; potential contributions of this work to flood and sediment control dictate that Federal and State agencies finance a substantial portion of the corrective program.

Costs of treatment range from \$354 to \$508 per mile depending on the class of road and varying with the physiographic area. In the brown loam and clay hills, costs vary from \$387 to \$508 per mile; in the deep loess, where treatments involve less movement of earth, estimated costs will range from \$354 to \$475. When adequately installed, maintenance of the measures will entail no special expense.

Installing erosion-control measures on public roads will cost more than \$2,000,000 (table 13). At least 40 percent of the cost or \$825,000 should be met from Federal funds with the State and counties supplying the remainder. If additional Federal funds are needed to

²² Excluding farm roads which can be treated adequately under regular farm-improvement plans.

implement these measures, an amount totaling perhaps 65 percent of the cost can be justified on the basis of the contribution of this work to off-site public benefits. Treatment of approximately 65 miles of road within the Coffeeville land-utilization project in the Yalobusha area is properly a Federal responsibility and would be financed entirely from Federal funds.

TABLE 13.—*Cost of installing erosion-control measures on public roads in the watershed*

Drainage unit	Roads requiring treatment	Cost per mile	Federal	State and county	Total
	<i>Miles</i>				
Coldwater.....	823	\$411	\$135, 268	\$202, 901	\$338, 169
Yocona.....	638	407	103, 950	155, 925	259, 875
Yalobusha.....	1, 108	425	194, 921	275, 983	470, 904
North Bluff.....	839	402	144, 056	193, 364	337, 420
South Bluff.....	1, 542	400	246, 696	370, 045	616, 741
Total.....	4, 950	409	824, 891	1, 198, 218	2, 023, 109

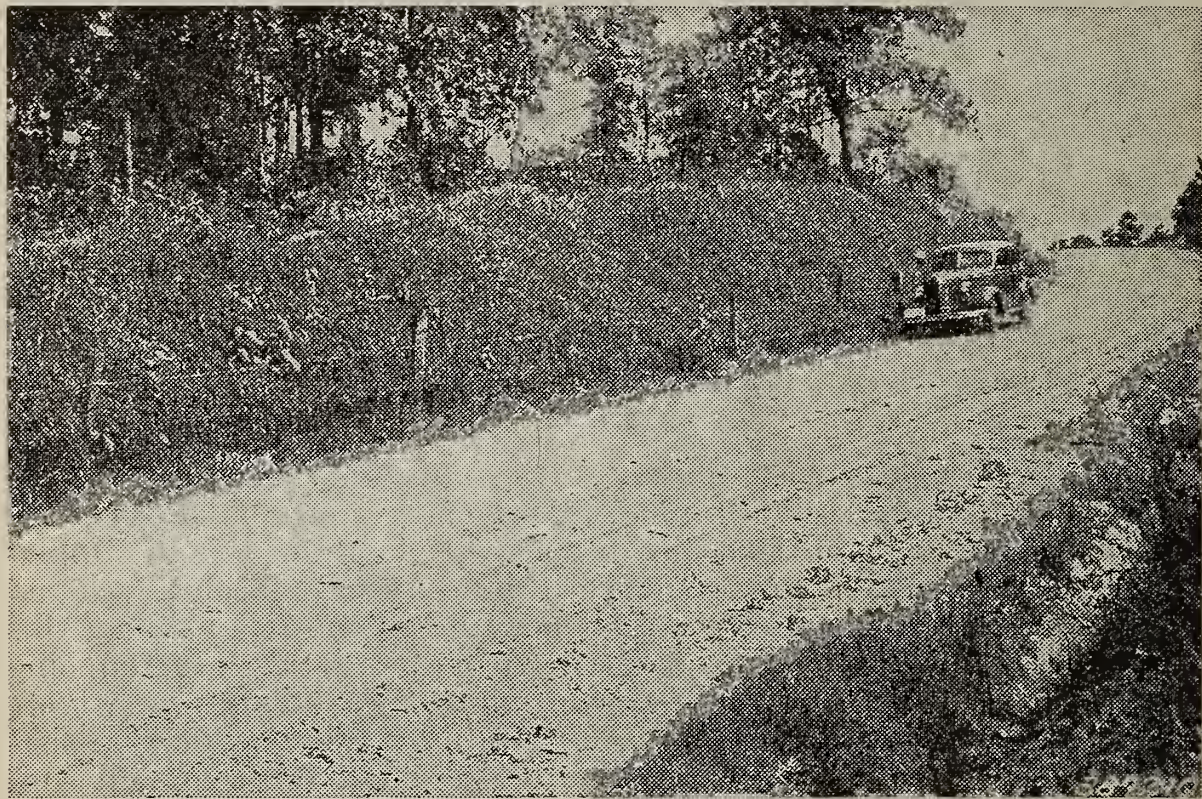


PLATE 17.—A roadbank in Marshall County that has been stabilized by the methods recommended for use over the entire watershed.

THE PROGRAM SUMMARIZED

Installation of the recommended program involves comprehensive and integrated treatment of 2,353,000 acres or 80 percent of all rural lands in the Coldwater, Yocona, Yalobusha, and Bluff units exclusive of areas purchased by the United States Engineer Department for flood-control reservoirs. The program will require 20 years to complete, although certain measures can be installed fully during the first 5 years.

The proposed schedule of work as outlined in table 14 involves (1) public acquisition of 730,000 acres of submarginal lands as an implementing measure to facilitate flood-control treatments; (2) establishment of an effective fire-control system to protect more than 1½ million acres of public and private forest lands, including those in reservoir areas and in noncooperating private ownership; (3) reforestation of 170,000 acres of submarginal lands, including about 47,000 acres of gullied land requiring special erosion-control measures; (4) timber-management measures on 1,176,000 acres of existing and proposed forest lands, including 532,000 acres to remain in private ownership; (5) soil- and water-conserving measures on 269,000 acres of cropland through the adoption of improved cropping practices and the construction of terraces; (6) construction and maintenance of 382 miles of diversion terraces to protect croplands against damaging run-off from adjacent areas; (7) establishment of perennial vegetation on 54,000 acres of critically eroding cropland intermingled with and endangering other arable lands; (8) treatment of 407,000 acres of existing and proposed pasture lands through such measures as contour furrowing, fertilizing, seeding and planting, establishment of erosion control structures, fencing, and general maintenance; and (9) treatment of 4,950 miles of public roads to eliminate an important source of sediment.

Execution of such a program is predicated on utilizing all lands according to their highest potential uses commensurate with flood-control objectives and hence involves not only changes in management but also numerous adjustments in the use of all participating lands (table 15). In the future, cultivated land will aggregate about 704,000 acres, a reduction of 101,000 from the gross acreage presently in crops. The forest acreage will be increased by more than 282,000 acres to a total of 1,176,000 acres, the increase coming largely through the conversion of extensive areas of worn-out open lands to forest use; less than 10,000 acres of existing forest lands are suitable for conversion to cropland or pasture. There will be a net increase in pasture land amounting to about 14,000 acres, the proposed future acreage totaling about 445,000 acres. Only 64 percent of the proposed pasture acreage is presently in pasture use, the remainder being largely in cultivation or idle. The latter conversions will more than offset the large acreage of pasture land which in the future must be shifted to forest use or to a lesser extent to cultivation.

TABLE 14.—Extent of remedial measures recommended for public and private land

Ownership and drainage unit	Land acquisition	Forest land measures			Cultivated land measures			Pasture land measures						Road erosion control
		Fire protection	Reforestation and erosion control	Timber management	Improved cropping practices and terraces	Diversification	Establishment perennial cover	Contouring and ground preparation	Fertilizing	Seeding and planting	Fencing	Erosion control structures	Mowing	
	<i>Acres</i>		<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Miles</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Number</i>	<i>Acres</i>	<i>Miles</i>
Public lands:														
Coldwater.....	70,561	77,141	17,680	54,342	2,049	2.5	0	9,174	10,050	9,904	10,935	181	11,319	823
Yocona.....	107,277	114,931	12,254	104,568	1,427	1.5	0	7,503	8,330	8,145	9,223	168	9,820	638
Yalobusha.....	187,994	216,083	8,049	187,674	1,034	.9	0	7,886	8,954	8,649	9,988	153	10,874	1,108
North Bluff.....	83,092	65,964	18,406	65,793	2,163	2.1	0	12,577	13,272	13,272	15,962	750	17,867	839
South Bluff.....	280,917	231,147	37,133	230,837	5,242	5.5	0	27,975	29,818	29,700	34,935	1,374	38,359	1,542
Total.....	1,729,841	2,705,266	93,522	644,214	11,915	12.5	0	65,115	70,424	69,670	81,043	2,626	88,239	4,950
Private land:														
Coldwater.....	---	159,071	20,524	107,941	64,885	86.1	14,536	67,044	71,773	71,169	82,561	2,906	82,561	---
Yocona.....	---	85,787	4,541	57,355	21,999	42.9	3,094	20,015	22,683	21,877	24,940	456	24,940	---
Yalobusha.....	---	225,329	2,835	129,272	52,620	52.7	7,134	48,254	61,115	54,154	66,537	517	66,537	---
North Bluff.....	---	153,519	24,237	97,646	53,936	66.3	16,145	58,304	61,003	60,294	73,032	3,054	73,032	---
South Bluff.....	---	219,289	24,141	139,447	63,332	121.2	12,718	63,891	68,857	68,367	78,809	2,304	78,809	---
Total.....	---	842,995	76,278	531,661	256,772	369.2	53,627	257,508	285,431	275,861	325,879	9,237	325,879	---
All lands:														
Coldwater.....	70,561	236,212	38,204	163,283	66,934	88.6	14,536	76,218	81,823	81,073	93,496	3,087	93,880	823
Yocona.....	107,277	200,718	16,795	161,923	23,426	44.4	3,094	27,518	31,013	30,022	34,163	624	34,760	638
Yalobusha.....	187,994	441,412	10,884	316,946	53,654	53.6	7,134	56,140	70,069	62,803	76,525	670	77,411	1,108
North Bluff.....	83,092	219,483	42,643	163,439	56,099	68.4	16,145	70,881	74,275	73,566	88,994	3,804	90,899	839
South Bluff.....	280,917	450,436	61,274	370,284	68,574	126.7	12,718	91,866	98,675	98,067	113,744	3,678	117,168	1,542
Total.....	1,729,841	1,548,261	169,800	1,175,875	268,687	381.7	53,627	322,623	355,855	345,531	406,922	11,863	414,118	4,950

¹ Does not include 29,422 acres already in public ownership, exclusive of reservoir areas.

² Includes forest within reservoir areas.

³ Includes both cooperating and noncooperating private land.

TABLE 15.—*Proposed adjustments in use for rural lands to be treated under the recommended program*

Present use		Future use			
Type	Area	Forest	Cultivation	Pasture	Other
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Forest.....	893,682	883,967	1,883	7,832	-----
Cultivation.....	804,806	85,981	628,208	90,617	-----
Pasture.....	431,165	114,179	30,386	286,600	-----
Idle.....	185,560	81,917	43,577	60,066	-----
Other.....	37,324	9,831	-----	-----	27,493
Total.....	2,352,537	1,175,875	704,054	445,115	27,493

The total cost of the program amounts to approximately \$25,275,000. Of this, the cost of installing the measures amounts to nearly \$18,500,000 (table 16). The estimated cost of purchasing the proposed public lands and their treatment is \$9,200,000; of roadside treatment is \$2,025,000; and of treating the privately owned lands is \$7,200,000. In addition, further planning and surveys and supervision is estimated to cost \$2,550,000; contingencies, \$1,500,000; and family rehabilitation, \$2,800,000.

Maintenance of the completely installed program exclusive of technical planning and supervision, will cost about \$2,380,000 annually after the twentieth year and \$25,186,000 during the period of installation (table 17). Maintenance of measures on public lands will cost \$353,000 per year after the twentieth year and \$3,874,000 for the total installation period. The greater part of the maintenance expense will apply to farm-land measures on private lands totaling \$21,312,000 for the 20-year installation period and \$2,027,000 annually thereafter. Technical supervision of maintenance will cost approximately \$120,000 annually after the twentieth year.

Cost of the program during the 20-year installation period including supervision and annual maintenance will total more than \$50,000,000 (table 18). The greater part of the 20-year costs, i. e., about \$30,000,000, or 59 percent, will be incurred in treating cropland and pastures. Forest land treatment accounts for only 11 percent of the 20-year cost, land acquisition 13 percent, and highway erosion-control measures 4 percent. After the twentieth year, costs of maintaining cropland and pasture land measures will total \$2,155,000 or 86 percent of the total annual cost, the balance representing maintenance-operation charges for forest land measures and technical services.

The proposed distribution of costs and annual requirement of funds are shown in table 19. First-year costs will amount to \$1,549,000 and will increase progressively up to \$3,372,000 the twentieth year of the program. Of the total 20-year cost amounting to \$47,660,000, 48 percent or \$22,942,000 is chargeable to private sources of funds, 49 percent or \$23,477,000 to Federal funds, and the balance of \$1,241,000 to State and local public funds. Of the total annual cost after the twentieth year, \$1,998,400 is a private contribution, \$485,300 is Federal, and \$16,300 is chargeable to State and local public agencies.

TABLE 16.—Cost of installing recommended remedial measures by land-ownership classes and measures¹

Ownership and drainage unit	Land acquisition	Forest land measures		Cultivated land measures			Pasture land measures					Road-erosion control	All measures
		Fire protection	Reforestation and erosion control	Terraces	Diversion terraces	Establishing perennial cover	Contouring and ground preparation	Fertilizing	Seeding and planting	Fencing	Erosion-control structures		
Public lands:													
Coldwater-----	\$583,333	\$7,678	\$218,651	\$18,749	\$151	0	\$23,118	\$39,698	\$76,855	\$40,678	\$90	\$338,169	\$1,347,170
Yocona-----	874,327	19,354	150,190	13,057	91	0	18,908	32,904	63,205	34,310	84	259,875	1,466,335
Yalobusha-----	1,721,225	37,338	96,266	9,461	54	0	19,873	35,368	67,116	37,155	77	470,904	2,494,837
North Bluff-----	731,239	8,098	226,801	19,791	127	0	31,694	52,424	102,991	59,379	375	337,420	1,570,339
South Bluff-----	2,635,526	49,438	446,466	47,964	333	0	70,497	117,781	230,472	129,958	687	616,741	4,345,863
Total-----	6,545,650	121,936	1,138,374	109,022	756	0	164,090	278,175	540,639	301,480	1,313	2,023,109	11,224,544
Private land:													
Coldwater-----	0	15,832	259,854	301,715	5,209	\$171,525	93,862	211,730	534,479	245,206	1,453	0	1,840,865
Yocona-----	0	14,469	59,615	102,296	2,595	36,509	28,021	66,915	164,296	74,072	228	0	549,016
Yalobusha-----	0	38,939	37,006	244,683	3,188	84,183	67,555	180,289	406,697	197,615	259	0	1,260,414
North Bluff-----	0	18,849	309,230	250,802	4,011	190,510	81,626	179,959	452,808	216,905	1,527	0	1,706,227
South Bluff-----	0	46,894	309,526	294,494	7,333	150,072	89,447	203,128	513,436	234,063	1,152	0	1,849,545
Total-----	0	134,983	975,231	1,193,990	22,336	632,799	360,511	842,021	2,071,716	967,861	4,619	0	7,206,067
All lands:													
Coldwater-----	583,333	23,510	478,505	320,464	5,360	171,525	116,980	251,428	611,334	285,884	1,543	338,169	3,188,035
Yocona-----	874,327	33,853	209,805	115,353	2,686	36,509	46,929	99,819	227,501	108,382	312	259,875	2,015,351
Yalobusha-----	1,721,225	76,277	133,272	254,144	3,242	84,183	87,428	215,657	473,813	234,770	336	470,904	3,755,251
North Bluff-----	731,239	26,947	536,031	270,593	4,138	190,510	113,320	232,383	555,799	276,284	1,902	337,420	3,276,566
South Bluff-----	2,635,526	96,332	755,992	342,458	7,666	150,072	159,944	320,909	743,908	304,021	1,839	616,741	6,195,408
Total-----	6,545,650	256,919	2,113,605	1,303,012	23,092	632,799	524,601	1,120,196	2,612,355	1,269,341	5,932	2,023,109	18,430,611

¹ This table does not include cost of planning surveys and supervision amounting to \$2,555,426; contingency items, etc., amounting to \$1,487,790; or family rehabilitation cost amounting to \$2,800,000. These items have been included in cost summaries shown in table 18.

TABLE 17.—Cost of maintaining recommended remedial measures by land-ownership classes and measures ¹

Ownership and drainage unit	Forest land measures ²		Cropland measures ³		Pasture land measures ⁴		All measures	
	Total during installation	Annual after twentieth year	Total during installation	Annual after twentieth year	Total during installation	Annual after twentieth year	Total during installation	Annual after twentieth year
Public land:								
Coldwater.....	\$99,422	\$7,368	\$163,727	\$15,619	\$201,096	\$21,168	\$464,245	\$44,155
Yocona.....	212,565	15,295	116,853	11,147	174,448	18,363	503,866	44,805
Yalobusha.....	429,897	30,139	88,335	8,426	193,183	20,335	711,415	58,900
North Bluff.....	112,141	8,423	175,209	16,714	317,395	33,410	604,745	58,547
South Bluff.....	485,162	34,648	422,619	40,316	681,454	71,732	1,589,235	146,696
Total.....	1,339,187	95,873	966,743	92,222	1,567,576	165,008	3,873,506	353,103
Private land:								
Coldwater.....	279,175	22,256	4,232,173	405,044	649,877	68,408	5,161,225	495,708
Yocona.....	183,428	13,775	1,377,618	131,727	190,513	20,054	1,751,559	165,556
Yalobusha.....	487,537	35,165	3,698,055	353,431	514,463	54,154	4,700,055	442,750
North Bluff.....	286,202	22,003	3,723,240	356,563	563,549	59,321	4,572,991	437,887
South Bluff.....	495,910	36,266	4,014,441	384,143	616,303	64,874	5,126,654	485,283
Total.....	1,732,252	129,465	17,045,527	1,630,908	2,534,705	266,811	21,312,484	2,027,184
All lands:								
Coldwater.....	378,597	29,624	4,395,900	420,663	850,973	89,576	5,625,470	539,863
Yocona.....	395,993	29,070	1,494,471	142,874	364,961	38,417	2,255,425	210,361
Yalobusha.....	917,434	65,304	3,786,390	361,857	707,646	74,489	5,411,470	501,650
North Bluff.....	398,343	30,426	3,898,449	373,277	880,944	92,731	5,177,736	496,434
South Bluff.....	981,072	70,914	4,437,060	424,459	1,297,757	136,606	6,715,889	631,979
Total.....	3,071,439	225,338	18,012,270	1,723,130	4,102,281	431,819	25,185,990	2,380,287

¹ Does not include cost of technical planning and supervision amounting to \$119,651.

² Includes fire protection and timber management.

³ Includes crop rotation, maintenance of terraces, and perennial cover.

⁴ Includes mowing, fertilizing, and maintenance of fences.

TABLE 18.—Summary of program costs by measures

Measure	Installation and maintenance during 20-year installation period		Annual maintenance operation after 20th year	
	Cost	Distribution	Cost	Distribution
Land acquisition.....	\$6,545,650	Percent 13		Percent
Forest land treatment.....	5,441,963	11	\$225,338	9
Cropland treatment.....	19,971,173	40	1,723,130	69
Pasture land treatment.....	9,634,706	19	431,819	17
Control of road erosion.....	2,023,109	4		
Family rehabilitation.....	2,800,000	5		
Technical planning and contingencies.....	4,043,216	8	119,651	5
Total.....	50,459,817	100	2,499,938	100

TABLE 19.—*Annual requirement of funds from public and private sources for installation and maintenance of the recommended remedial measures.*

Year	Federal Government	State and local government	Private			Grand total
			Cash	Labor and farm material	Total	
1.....	\$1, 108, 867	\$240, 120	\$102, 701	\$97, 595	\$200, 296	\$1, 549, 283
2.....	1, 141, 567	240, 596	197, 370	102, 872	300, 242	1, 682, 405
3.....	1, 174, 267	241, 073	292, 038	108, 150	400, 188	1, 815, 528
4.....	1, 206, 966	241, 549	386, 707	113, 427	500, 134	1, 948, 649
5.....	1, 239, 666	242, 026	481, 376	118, 704	600, 080	2, 081, 772
6.....	1, 070, 005	2, 382	575, 596	123, 981	699, 577	1, 771, 964
7.....	1, 084, 820	2, 382	669, 816	129, 258	799, 074	1, 886, 276
8.....	1, 099, 634	2, 382	764, 036	134, 536	898, 572	2, 000, 588
9.....	1, 114, 449	2, 382	858, 255	139, 813	998, 068	2, 114, 899
10.....	1, 129, 264	2, 382	952, 475	145, 090	1, 097, 565	2, 229, 211
11.....	1, 144, 078	2, 382	1, 046, 695	150, 367	1, 197, 062	2, 343, 522
12.....	1, 158, 893	2, 382	1, 140, 915	155, 644	1, 296, 559	2, 457, 834
13.....	1, 173, 708	2, 382	1, 235, 135	160, 922	1, 396, 057	2, 572, 147
14.....	1, 188, 522	2, 382	1, 329, 355	166, 199	1, 495, 554	2, 686, 458
15.....	1, 203, 337	2, 382	1, 423, 575	171, 476	1, 595, 051	2, 800, 770
16.....	1, 218, 152	2, 382	1, 517, 794	176, 753	1, 694, 547	2, 915, 081
17.....	1, 232, 966	2, 382	1, 612, 014	182, 030	1, 794, 044	3, 029, 392
18.....	1, 247, 781	2, 382	1, 706, 234	187, 308	1, 893, 542	3, 143, 705
19.....	1, 262, 596	2, 382	1, 800, 454	192, 585	1, 993, 039	3, 258, 017
20.....	1, 277, 410	2, 382	1, 894, 675	197, 862	2, 092, 537	3, 372, 329
Total.....	123, 476, 948	1, 241, 094	19, 987, 216	2, 954, 572	22, 941, 788	147, 659, 830
Annual after twentieth year..	485, 299	16, 268	1, 892, 827	105, 544	1, 998, 371	2, 499, 938

¹ Does not include \$2,800,000 provided for family rehabilitation.TABLE 19a.—*Cost of remedial program on Yazoo watershed by source of funds*

Measures	Private	Public costs		Total
		Local	Federal	
Land acquisition.....			\$6, 545, 650	\$6, 545, 650
Forest land:				
Protection.....			256, 919	256, 919
Reforestation.....			2, 113, 605	2, 113, 605
Cultivated land:				
Terraces.....	\$885, 820		417, 192	1, 303, 012
Diversion terraces.....	6, 545		16, 547	23, 092
Establishing cover.....	107, 259		525, 540	632, 799
Pasture land:				
Contouring, etc.....	348, 469		176, 132	524, 601
Fertilizing.....	114, 418		1, 005, 778	1, 120, 196
Seeding and planting.....	413, 721		2, 198, 634	2, 612, 355
Fencing.....	478, 994		790, 347	1, 269, 341
Erosion control.....			5, 932	5, 932
Road-erosion control.....		\$1, 198, 218	824, 891	2, 023, 109
Surveys and contingencies.....			4, 043, 216	4, 043, 216
Family relocation.....			2, 800, 000	2, 800, 000
Total.....	2, 355, 226	1, 198, 218	21, 720, 383	25, 273, 827

TABLE 19b.—Cost of installing recommended remedial measures by source of funds ¹

Source of funds and drainage unit	Land acquisition	Forest land measures		Cultivated land measures			Pasture land measures					Road erosion control	All measures
		Fire protection	Reforestation and erosion control	Terraces	Diversion terraces	Establishing perennial cover	Contouring and ground preparation	Fertilizing	Seeding and planting	Fencing	Erosion control		
Private:													
Coldwater.....				\$223,840	\$1,555	\$29,075	\$90,744	\$28,790	\$106,735	\$121,350			\$602,089
Yoeona.....				75,890	775	6,199	27,070	9,075	32,810	36,650			188,469
Yalobusha.....				181,530	965	14,250	65,260	24,445	81,215	97,814			465,479
North Bluff.....				186,070	1,195	32,290	78,890	24,468	90,425	107,340			520,678
South Bluff.....				218,490	2,055	25,445	86,505	27,640	102,536	115,840			578,511
Total.....				885,820	6,545	107,259	348,469	114,418	413,721	478,994			2,355,226
Local public:													
Coldwater.....												202,901	202,901
Yoeona.....												155,925	155,925
Yalobusha.....												275,983	275,983
North Bluff.....												193,364	193,364
South Bluff.....												370,045	370,045
Total.....												1,198,218	1,198,218
Federal:													
Coldwater.....	\$583,333	\$23,510	\$478,505	96,624	3,805	142,450	26,236	222,638	504,599	164,534	\$1,543	135,268	2,383,045
Yoeona.....	874,327	32,853	209,805	39,463	1,911	30,310	19,859	90,744	194,691	71,732	312	103,950	1,670,957
Yalobusha.....	1,721,225	76,277	133,272	72,614	2,277	69,933	22,168	191,212	392,598	136,956	336	194,921	3,013,789
North Bluff.....	731,239	26,947	536,031	84,523	2,943	158,220	34,430	207,915	465,374	168,944	1,902	144,056	2,562,524
South Bluff.....	2,635,526	96,332	755,992	123,968	5,611	124,627	73,439	293,269	641,372	248,181	1,839	246,696	5,246,852
Total.....	6,545,650	256,919	2,113,605	417,192	16,547	525,540	176,132	1,005,778	2,198,634	790,347	5,932	824,891	14,877,167
Grand total.....	6,545,650	256,919	2,113,605	1,303,012	23,092	632,799	524,601	1,120,196	2,612,355	1,269,341	5,932	2,023,109	18,430,611

¹ This table does not include cost of planning surveys and supervision amounting to \$2,555,426, contingency terms amounting to \$1,487,790, or family relocation amounting to \$2,800,000, all of which are Federal expenditures.

To install and maintain the measures during the 20-year installation period will require about 17,716 man-years of labor (table 20). The labor to install and maintain cropland and pasture-improvement measures will be supplied largely through more complete use of the available time of cooperators and will not usually require hiring extra assistance. Measures of a public nature, such as the forest land and highway treatments, will furnish 6,246 man-years of employment during the 20-year period or average yearly employment amounting to 312 man-years. This will provide additional part-time employment to local people and will help to offset temporary reductions in income which may sometimes result from carrying out necessary land-use adjustments. Labor requirements for maintaining the program after the twentieth year are relatively small and amount to only 781 man-years.

TABLE 20.—*Labor requirements to install and maintain a remedial program*

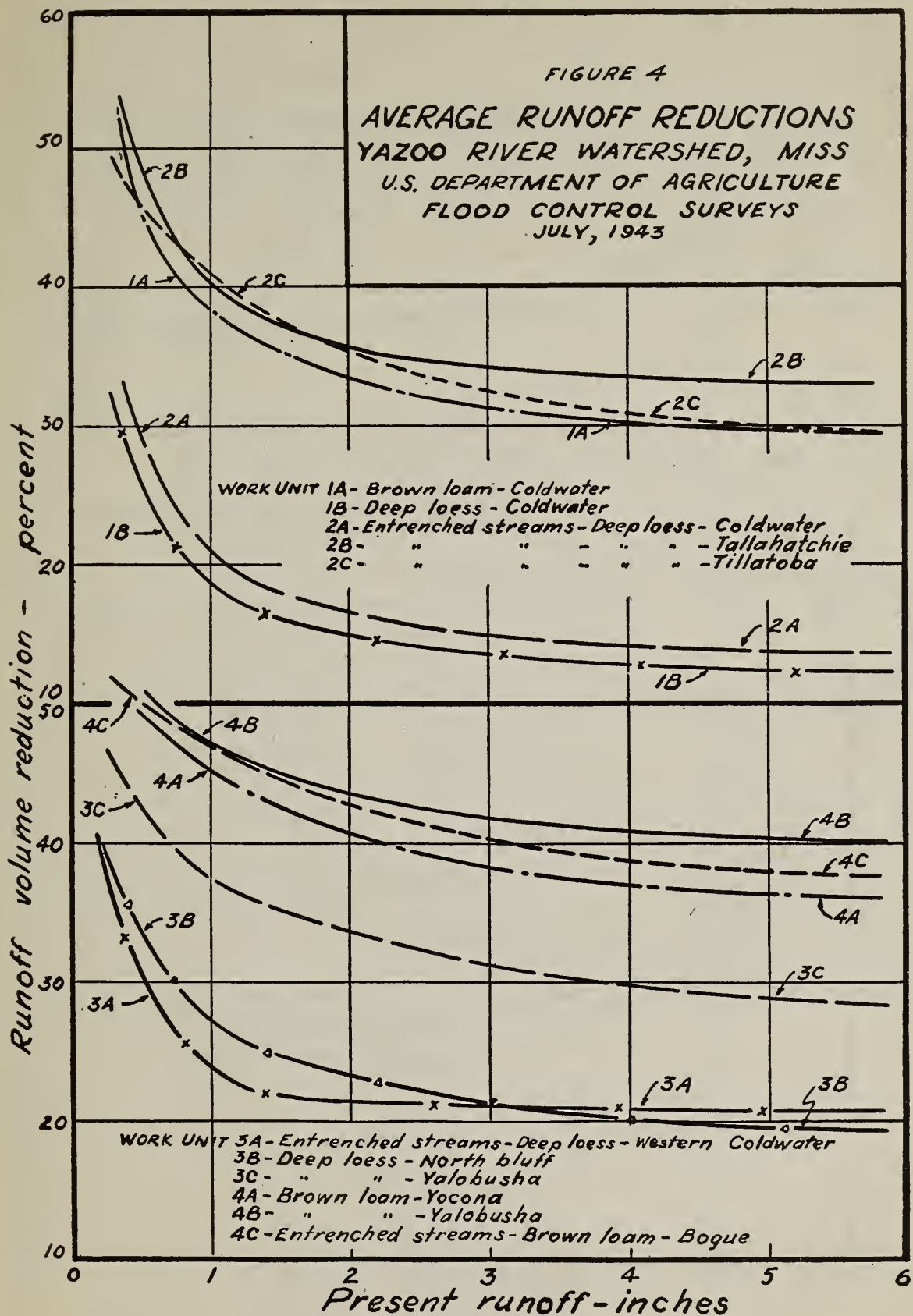
Treatment	Installation and maintenance during installation period	Annual maintenance after twentieth year
	<i>Man-years</i>	<i>Man-years</i>
Forest-land measures.....	4,046	138
Treatment of cropland.....	5,295	237
Pasture improvement.....	6,175	406
Erosion control on public roads.....	2,200	-----
Total.....	17,716	781

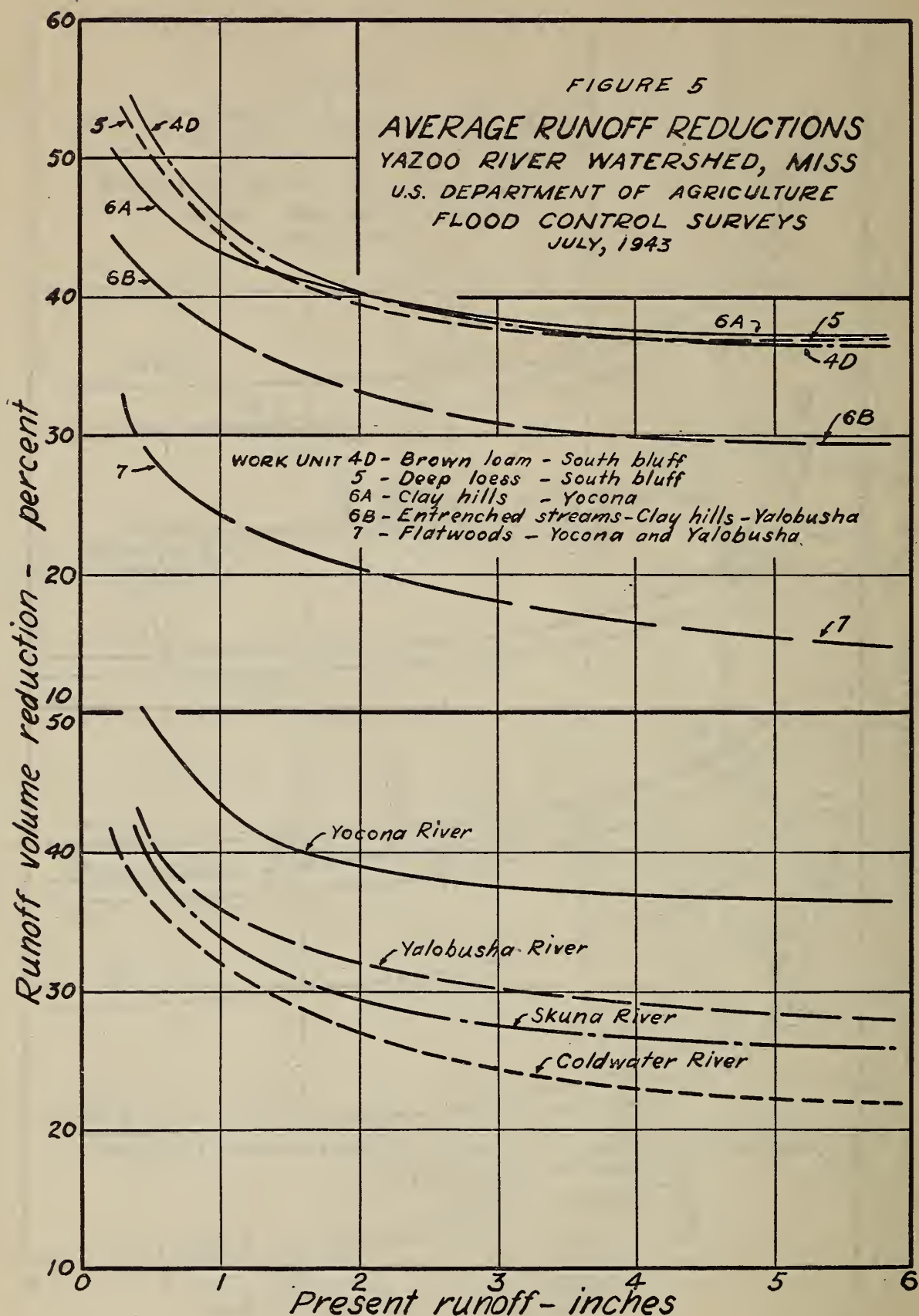
CHAPTER IV. BENEFITS FROM THE REMEDIAL PROGRAM

Benefits from the recommended program are of two major classes: (1) The off-site or flood-control benefits and (2) the on-site or conservation benefits. Off-site benefits of the program will accrue on flood-plain property as a result of reduced flooding and sedimentation. On-site benefits will accrue on treated lands as a direct result of conserving water and building up the soil and will consist of increased yields of crops, forage, and timber or reduced operating or maintenance costs.

OFF-SITE BENEFITS TO VALLEY LANDS AND FLOOD CONTROL WORKS

Off-site benefits provide ample justification for the recommended flood-control program. The benefits are public in character, since they accrue to society at large and result from control measures which are applied to lands other than those benefited. Inasmuch as 82 percent of all farms in the watershed include some bottom land, most people incurring costs of land treatment will also share in the flood-control benefits. Substantial off-site benefits will accrue to lands in the alluvial fans which are unattached to any lands participating in the program.





Benefits from run-off reductions.

Storm run-off will be reduced materially soon after control measures are installed, even on severely eroded lands where forest plantings will check surface run-off substantially in only a few years. There will be a delay in the attainment of benefits on a watershed-wide scale because of the impracticability of effecting major land-use adjustments over the entire area in a short period of time. As planned, the program will be installed over a 20-year period and more than 65 percent of the off-site benefits from reducing floodwaters will be attained by that time. In the tenth year after the program is completely installed, almost 90 percent of the ultimate floodwater benefits will be realized and 100 percent of yearly benefits will be attained 25 years after all installations are complete.²³ When the program becomes fully effective flood flows will be decreased on the average by the percentages shown by the curves of figures 4 and 5.

Floods formed the alluvial valleys of this basin long before the land was subjected to improper use and floods cannot be entirely eliminated even when all lands are properly devoted to their best potential uses. The recommended adjustments in land use, however, will cause a marked reduction in surface run-off, with a result that some floods will be entirely prevented and others will be so reduced as to permit much more profitable utilization of the alluvial lands. There are now from 1 to 13²⁴ floods annually on any one stream system; in the future this frequency will roughly be halved and on an average the aggregate acreage of flood plain inundated annually will be only about 50 percent of that now flooded.²⁵

Within 25 years after the program is installed, annual floodwater benefits will amount to approximately \$890,000, of which 93 percent will be a direct reduction in damage to crops and property. The remaining 7 percent will represent the enhanced value of land within flood-control reservoir areas, the presently wooded flood plain of the main stem of the Coldwater River; and alluvial fan areas of the delta. More intensive use of these lands will be feasible when the frequency of flooding has been reduced; land that now is flooded more often than once in 4 years, and usually every year, will be flooded less frequently and thus will be available for crop production. In the reservoir areas, this benefit will result from more land being available for leasing to private interests, as a common rule of thumb for determining leasable land is that it be flooded no more frequently than once in 4 years. Along the main stream of the Coldwater and on the delta alluvial fans, most of the land capable of yielding this class of benefit is now in woods because of frequent flooding. Additional small areas of woodland occur on flood plains in other parts of the watershed and undoubtedly will receive benefits of this type; however, such benefits have not been evaluated for these scattered areas, since the latter are intermingled with other flood-plain lands, the preponderance of which have already been developed intensively for farming use.

²³ See appendix, exhibit E.

²⁴ This does not mean that the entire stream system will be flooded the total number of times shown, but that the number of floods given will occur on some streams in the system. It is not uncommon at present, however, to have as many as 4 to 6 floods on one stream during one growing season.

²⁵ Some areas are inundated several times in the same year by successive floods and the aggregate acreage inundated in a year may be several times the flood-plain area.

A summary of floodwater benefits by drainage units is shown in table 21.

Benefits from reduced sedimentation.

Benefits from reducing sedimentation will not accrue as rapidly as those resulting from reductions in floodwater. The recommended remedial measures will curtail sharply soil-erosion rates long before the infiltration capacity of soils has been fully restored. Although these influential effects will confer some immediate benefits, reductions in sedimentation will increase progressively and will not reach a maximum for many years.

Present trends in sedimentation damage by deposition and swamping are upward. Consequently the stabilization of erosion will check these trends immediately and reverse them by the time all measures are installed. This will result in relatively early benefits from the prevention of future damage. As the rate of erosion is further decreased and sediment contributions fall below the critical rate,²⁶ the benefits from alleviating past damage will begin to accrue and finally will surpass in value all other types of off-site benefits.

Calculations show that at present the annual contribution of sediment to stream systems totals about 89,000,000 tons for the watershed (table 22). Twenty years after the program has been installed, the annual contribution will total an estimated 33,000,000 tons instead of increasing to 137,000,000 tons.

TABLE 21.—*Monetary value of off-site benefits resulting from anticipated reductions in run-off*

[Benefits shown have not been reduced to present values]

Drainage unit	Annual flood damage to crops and property			Annual productivity of flood-plain lands ¹			Total benefits
	Present	Future ²	Decrease or benefits	Present ³	Future	Increase or benefits	
Coldwater.....	\$271, 729	\$158, 520	\$113, 209	\$4, 155	\$37, 689	\$33, 534	\$146, 743
Yocona.....	179, 988	88, 981	91, 007	0	4, 264	4, 264	95, 271
Yalobusha.....	567, 829	320, 067	247, 762	0	10, 728	10, 728	258, 490
North Bluff.....	122, 431	71, 725	50, 706	0	0	0	50, 706
South Bluff.....	166, 643	71, 320	95, 323	0	0	0	95, 323
Delta.....	490, 791	262, 108	⁴ 228, 683	1, 921	16, 060	14, 139	242, 822
Watershed.....	1, 799, 411	972, 721	826, 690	6, 076	68, 741	62, 665	889, 355

¹ Land on which the frequency of flooding will be reduced by the proposed measures sufficiently to permit cultivation. Values for Coldwater unit apply to 4,155 acres of flood plain in the main stream of Coldwater River above the Arkabutla Reservoir and to 1,124 acres within the reservoir proper. Values for Yocona unit apply to 995 acres within the Enid Reservoir. In the Yalobusha unit, 2,539 acres in the New Grenada Reservoir will be benefited, whereas in the delta 583 acres of alluvial fan areas adjacent to the North Bluff unit and 1,338 acres of similar land adjacent to the South Bluff unit will have their value enhanced through more intensive use.

² Approximately twenty-fifth year after program installation is completed.

³ Actually future without conversions.

⁴ Flood reduction benefits in the delta consist of \$10,787 accruing to overflow areas along the main stream and \$217,896 on alluvial fans formed by streams draining the North and South Bluff units. All delta benefits are the result of land treatment in the North and South Bluff units.

²⁶ The critical rate is defined as the number of tons of sediment per year which stream systems can receive and safely dispose of without causing any net harmful effects from sedimentation. This rate amounts to about 36,000,000 tons per year for the watershed as a whole and will be reached about 10 years after the complete installation of the program.

TABLE 22.—*Comparative annual rates of sediment contributed to streams from treated and untreated uplands*

Drainage unit	Present rate	Twentieth year ¹		Eightieth year	
		With program	Without program	With program	Without program
	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>
Coldwater.....	21, 000, 000	8, 000, 000	32, 000, 000	7, 000, 000	41, 000, 000
Yocona.....	6, 000, 000	2, 000, 000	10, 000, 000	2, 000, 000	12, 000, 000
Yalobusha.....	8, 000, 000	2, 000, 000	13, 000, 000	2, 000, 000	16, 000, 000
North Bluff.....	23, 000, 000	9, 000, 000	34, 000, 000	9, 000, 000	45, 000, 000
South Bluff.....	31, 000, 000	12, 000, 000	48, 000, 000	10, 000, 000	61, 000, 000
Watershed.....	89, 000, 000	33, 000, 000	137, 000, 000	30, 000, 000	175, 000, 000

¹ After the program is installed.

These estimated reductions in the rate of sediment contribution to flood plains will prevent sediment damages in the amount of about \$700,000 annually after the program has been in for 20 years. This benefit will increase to approximately \$1,750,000 in the eightieth year after installation. An even greater benefit, however, will be realized through the alleviation of past sediment damages although its rate of accrual is slower. As sedimentation falls below the critical rate, the increased transporting power of stream discharge will enable it to pick up sediment in the channels and flush it out of the drainage systems. This process will result in less overbank flooding as stream channels become enlarged; in the somewhat distant future, it will permit some beneficial siltation when floods that do go overbank transport and deposit fertile soil rather than coarse sand. The anticipated alleviation of past sediment damage is valued at only \$144,000 in the twentieth year after the program is installed but this type of benefit will increase in the eightieth year to more than \$2,300,000.

As the quantity of flood-borne sediment is increasing at an alarming rate, this represents a potential hazard to the operation of flood-control reservoirs in this watershed. The United States Engineer Department ²⁷ estimates that some structural alterations will be needed on the Enid Dam when the reservoir has lost about 12½ percent of its flood-storage capacity. Sediment source studies indicate that this condition will occur in some 100 years if sedimentation is uncontrolled. In the Arkabutla and New Grenada Reservoirs, the permissible storage loss will be about 17½ percent of total capacity and must be rectified in about 90 years. When the recommended program is carried out, sediment rates will be so reduced that indicated improvements should be unnecessary for over 300 years on the Arkabutla Reservoir, 500 years on the New Grenada Reservoir, and 600 years on the Enid Reservoir. For all practical purposes the program may be assumed to eliminate this sedimentation damage to reservoirs. The annual benefit of eliminating this damage is \$12,376, if the cost of improvements made necessary due to sedimentation is assumed to be \$9,000,000.

²⁷ Estimates obtained in conferences and correspondence with U. S. Engineer Department, Vicksburg, Miss.

Indirect benefits.

The effect of floods on transportation facilities, the interruption of regular or planned business, the reduction in farmer purchasing power, and many other indirect damages are suffered as the result of floods and damaging sediment. Indirect damages are considered to amount to at least one-fourth as much as all direct flood damages. Likewise, indirect flood-control benefits are assumed to accrue at the same ratio to direct flood-control benefits, although studies indicate a higher ratio could be adopted. They will amount to approximately \$335,000 annually.

ON-SITE CONSERVATION BENEFITS

On-site benefits, as the name applies, accrue on the land to which remedial measures are applied. They consist chiefly of increased yields of crops, livestock, and timber or they may take the form of reduced maintenance expenses as in the case of controlling erosion on public roads. In general, most on-site benefits accrue to private individuals, although the public will be the recipient of benefits accruing on public lands, such as increased revenue from the sale of timber stumpage, the rental of certain lands for agricultural and grazing use, and the savings in maintenance costs from controlling highway erosion.

The on-site benefits are of considerable practical importance from the standpoint of program accomplishment. They provide the main incentive for individual participation in establishing remedial measures. Practices that will demonstrably increase farm incomes by improving crop yields, doubling the carrying capacity of pastures, and multiplying by many times the present forest income, will appeal to land-owners and will enlist a type of cooperation that would be largely lacking if justification for this work depended solely on potential flood-control benefits accruing to the special advantage of other lands.

TABLE 23.—Annual on-site benefits after recommended program reaches full effectiveness ¹

[Benefits shown have not been reduced to present values]

Drainage unit	Benefits on open land		Benefits on wood-land		Benefits from road erosion control	Total benefits		
	Private	Public ²	Private	Public ³	Public ⁴	Private	Public	Total
Coldwater.....	\$1, 542, 507	\$33, 448	\$640, 144	\$127, 796	\$33, 590	\$2, 182, 651	\$194, 834	\$2, 377, 485
Yocona.....	651, 727	32, 231	665, 329	244, 429	31, 360	1, 317, 056	308, 020	1, 625, 076
Yalobusha.....	1, 510, 732	38, 792	1, 485, 055	497, 020	55, 400	2, 995, 787	591, 212	3, 586, 999
North Bluff.....	1, 277, 508	56, 621	869, 730	147, 598	29, 365	2, 147, 238	233, 584	2, 380, 822
South Bluff.....	1, 637, 709	124, 134	2, 033, 287	740, 523	63, 195	3, 670, 996	927, 852	4, 598, 848
Watershed.....	6, 620, 183	285, 226	5, 693, 545	1, 757, 366	212, 910	12, 313, 728	2, 255, 502	14, 569, 230

¹ Full effectiveness reached on open land 25 years after full installation of the program, on forest land in 58 years, and on road banks within a year after treatment.

² Rental of public land suitable for cultivation or pasture.

³ Represents stumpage value only.

⁴ Reduced maintenance costs.

The on-site benefits will total almost 15 million dollars annually after the program is fully effective and more than half of this annual amount will accrue the tenth year after the program is installed. When the program is fully effective, this increased income will be equivalent to an average return of \$478 annually for every rural family in the watershed plus an additional public income of over \$2,250,000 (table 23).

General economic benefits.

The prospective benefits are of such magnitude that either the public flood-control benefits or the private conservation benefits will amply justify the entire program. Many other benefits will result from accomplishment of the proposed program and will affect favorably the economy of the entire basin. Some of these are: Increased opportunities for employment; stabilization of agriculture and industry; more adequate recreational facilities; the alleviation of problems of indebtedness, tenancy, taxation, and public health. These benefits will have regional implications of considerable magnitude as well.

Installation of the program will require approximately 886 additional man-years of labor annually over the 20-year period. After the program has reached full effectiveness, the annual labor increase, including that required to harvest the added production of crops and timber, will amount to about 3,400 man-years.²⁸ Much additional labor will be required in the primary and secondary manufacture of products. The additional production from improved forests, for instance, will require about 6,700 man-years to operate local sawmills and several times this amount will be utilized in secondary processing enterprises. These increased outlets for labor will develop progressively after installation of the program but will not provide sufficient immediate employment to alleviate materially the problem of relocating families now occupying submarginal lands unsuitable for private ownership.

Increases in incomes and resultant higher standards of living will help meet the problems of indebtedness, taxation, tenancy, and related problems confronting the area. The proposed program will not directly solve these problems but will aid in their ultimate solution.

Incident to a public-purchase program will be the development of roads and recreational facilities to serve the area. Some few improvements of this nature have already been installed by public agencies now operating in the area, and an expanded public program will give impetus to fulfillment of these needs.

SUMMARY OF BENEFITS

When all measures have become fully effective, the monetary benefits from the recommended program will total almost \$21,000,000 annually (table 24). More than \$6,000,000 of these benefits is a direct result of reducing flood and sediment damage on valley lands and the remainder represents the on-site benefits accruing on treated lands. In addition, many intangible benefits will contribute materially toward the stabilization of agriculture and a higher standard of living.

²⁸ These labor increases are net changes and include a deduction for losses in farm labor as a result of the public-purchase program.

TABLE 24.—*Annual monetary benefits when the recommended program approaches maximum effectiveness*

[Benefits shown have not been reduced to present values]

Type of benefit	Drainage unit						Water-shed
	Cold-water	Yocona	Yalo-busha	North Bluff	South Bluff	Delta	
Public:							
Reduced flood damage to crops and property ¹ -----	\$113, 209	\$91, 007	\$247, 762	\$50, 706	\$95, 323	\$228, 683	\$826, 690
Enhanced productivity of flood-plain land ¹ -----	33, 534	4, 264	10, 728	-----	-----	14, 139	62, 665
Prevention and alleviation of sedimentation on flood plains ²	722, 794	303, 435	674, 194	706, 912	1, 086, 386	597, 337	4, 091, 058
Reduced sedimentation of reservoirs-----	18, 666	14, 425	41, 464	-----	-----	-----	74, 555
Indirect benefits to transportation, business, etc-----	222, 051	103, 283	243, 537	189, 404	295, 427	210, 040	1, 263, 742
Total off-site public benefits-----	1, 110, 254	516, 414	1, 217, 685	947, 022	1, 477, 136	1, 050, 199	6, 318, 710
Public on-site benefits ³ -----	194, 834	308, 020	591, 212	233, 584	927, 852	-----	2, 255, 502
All public benefits-----	1, 305, 088	824, 434	1, 808, 897	1, 180, 606	2, 404, 988	1, 050, 199	8, 574, 212
Private: Conservation or on-site benefits ³ -----	2, 182, 651	1, 317, 056	2, 995, 787	2, 147, 238	3, 670, 996	-----	12, 313, 728
All monetary benefits ⁴ -----	3, 487, 739	2, 141, 490	4, 804, 684	3, 327, 844	6, 075, 984	1, 050, 199	20, 887, 940

¹ Brought about through run-off reductions. Maximum effectiveness reached about 25 years after the program is installed.

² Includes prevention and alleviation of all forms of sedimentation damage including that causing increased flooding. Benefits shown are those that will accrue in 80 years after installation of the program. These benefits will increase indefinitely, since alleviation processes are gradual. They will level off to some extent after about 200 years.

³ These are benefits on open and forested land in public and private ownership. The benefits on open land will reach maximum effectiveness 25 years after installation of the program. Benefits on forested land will reach maximum effectiveness in about 60 years. Benefits, or reduced maintenance costs, on treated roadbanks will accrue immediately following treatment and amount to about 10 percent of all public on-site benefits.

⁴ Will accrue in full 80 years after installation of program and will continue to increase slightly thereafter.

When all future benefits, some of which may be realized at an early date and others many years later, are converted to an average annual basis they amount to the following:

Flood and sediment reduction-----	\$1, 675, 618
Conservation or on-site-----	6, 455, 851
Total-----	8, 131, 469

CHAPTER V. EVALUATION OF THE PROGRAM

Costs and benefits of the recommended flood-control program do not accrue at regular rates or in proportional amounts. Some measures entail high initial costs and yield deferred benefits while others are relatively inexpensive and confer substantial benefits almost immediately. Heretofore, costs and benefits have been discussed in terms of actual values as these will be incurred or realized at specific times in the future. In order to compare costs and benefits, it is necessary to eliminate the element of time by converting all such values to present worth and reducing the latter to average annual amounts.²⁹

²⁹ This program is evaluated using an interest rate of 3½ percent. Future costs and benefits are discounted to present-worth values by applying appropriate discount factors to each value each year until it levels off. The annual amount at the leveling-off point is capitalized and likewise reduced to present worth by the proper discount factor. 3½ percent of the sum of present-worth values represents an average annual value.

COSTS OF THE PROGRAM

The average annual cost of the recommended program will amount to \$3,565,388 or slightly more than \$1.50 per treated acre (table 25). Of this total cost, approximately 69 percent is private, 30 percent Federal, and about 1 percent State and local government. Costs per acre treated in the various drainage units are nearly uniform, amounting to \$1.47 in the Coldwater, \$1.34 in the North Bluff, \$1.51 in the Yalobusha, \$1.59 in the Yocona, and \$1.63 in the South Bluff.

TABLE 25.—Average annual cost of the flood-control remedial program

Drainage unit	Federal	State and local governments	Private	Total cost
Coldwater.....	\$143, 171	\$7, 353	\$485, 733	\$636, 257
Yocona.....	129, 719	5, 795	282, 151	417, 665
Yalobusha.....	242, 228	12, 234	609, 207	863, 669
North Bluff.....	160, 737	7, 243	389, 060	557, 040
South Bluff.....	388, 646	14, 450	687, 661	1, 090, 757
Total.....	1, 064, 501	47, 075	2, 453, 812	3, 565, 388

BENEFITS FROM THE PROGRAM

Average annual benefits will amount to \$8,131,469, of which 21 percent is flood-control or off-site benefits and 79 percent is the conservation benefits. Approximately one-third of all benefits are public and the remaining two-thirds will accrue to private interests (table 26). As with costs, the benefits per acre of land treated vary little between drainage units, being \$3.30 in the Yalobusha, \$3.12 in the Yocona, \$3.70 in the Coldwater, \$3.64 in the North Bluff, and \$3.44 in the South Bluff.

COMPARISON OF COSTS AND BENEFITS

For each dollar of annual cost of the proposed program, \$2.28 will be returned as benefits. Benefits per dollar of cost range from \$1.96 in the Yocona to \$2.72 in the North Bluff (table 27).

Federal participation in the recommended program is clearly justified, as the flood-reduction benefits alone have an appraised value approximately one and three-fifths times that of all Federal costs.

State and local governments will receive proportionately larger benefits having an aggregate value approximately four times that of contributed costs. Private interests are the major beneficiary. They will receive about \$2.25 of on-site benefits per dollar of cost and in addition will share in the greater part of the flood-reduction benefits.

On the basis of the foregoing, it is evident that a corrective flood-control program is fully justified in all portions of the watershed.

TABLE 26.—Average annual flood control and conservation benefits from the recommended program

[Present values of the benefits which are given in table 24]

Type of benefit	Cold-water	Yocona	Yalo-busha	North Bluff ¹	South Bluff ¹	Total
Public flood control benefits:						
Reduction of floodwater damage.....	\$67, 993	\$54, 659	\$148, 806	\$73, 925	\$151, 127	\$496, 510
Reduction of sedimentation.....	141, 675	55, 631	123, 233	182, 035	291, 397	793, 971
Reduction of reservoir siltation.....	3, 829	1, 617	6, 930	0	0	12, 376
Enhanced land use ²	20, 141	2, 561	6, 443	2, 577	5, 915	37, 637
All direct benefits.....	233, 638	114, 468	285, 412	258, 537	448, 439	1, 340, 494
Indirect benefits.....	58, 410	28, 617	71, 353	64, 634	112, 110	335, 124
Total.....	292, 048	143, 085	356, 765	323, 171	560, 549	1, 675, 618
Conservation benefits:						
Public.....	89, 342	128, 654	255, 333	112, 345	382, 957	968, 631
Private.....	1, 224, 452	546, 943	1, 272, 271	1, 079, 361	1, 364, 193	5, 487, 220
Total.....	1, 313, 794	675, 597	1, 527, 604	1, 191, 706	1, 747, 150	6, 455, 851
All monetary benefits:						
Public.....	381, 390	271, 739	612, 098	435, 516	943, 506	2, 644, 249
Private.....	1, 224, 452	546, 943	1, 272, 271	1, 079, 361	1, 364, 193	5, 487, 220
Grand total.....	1, 605, 842	818, 682	1, 884, 369	1, 514, 877	2, 307, 699	8, 131, 469

¹ Includes public flood-control benefits in the delta unit which result from reductions in run-off and sediment from these upland drainage units.² Made possible by the reduction in frequency of flooding.

TABLE 27.—Comparison of average annual costs and benefits of the recommended flood-control program

Item	Cold-water	Yocona	Yalo-busha	North Bluff	South Bluff	Total	Little Talla-hatchie ¹	Grand total
Federal costs.....	\$143, 171	\$129, 719	\$242, 228	\$160, 737	\$388, 646	\$1, 064, 501	\$138, 095	\$1, 202, 596
Flood reduction benefits....	292, 048	143, 085	356, 765	323, 171	560, 549	1, 675, 618	337, 727	2, 013, 345
Benefits per dollar of costs.....	2. 05	1. 10	1. 47	2. 01	1. 44	1. 57	2. 45	1. 67
State and local government costs.....	7, 353	5, 795	12, 234	7, 243	14, 450	47, 075	14, 920	61, 995
State and local government benefits.....	30, 332	28, 318	50, 026	26, 517	57, 065	192, 258	61, 218	253, 476
Benefits per dollar of costs.....	4. 13	4. 89	4. 09	3. 66	3. 95	4. 08	4. 10	4. 09
Total public costs.....	150, 524	135, 514	254, 462	167, 980	403, 096	1, 111, 576	153, 015	1, 264, 591
Total public benefits ²	381, 390	271, 739	612, 098	435, 516	943, 506	2, 644, 249	482, 777	3, 127, 026
Benefits per dollar of costs.....	2. 43	2. 01	2. 41	2. 59	2. 34	2. 38	3. 16	2. 47
Private costs.....	485, 733	282, 151	609, 207	389, 060	687, 661	2, 453, 812	311, 511	2, 765, 323
Private conservation benefits.....	1, 224, 452	546, 943	1, 272, 271	1, 079, 361	1, 364, 193	5, 487, 220	680, 084	6, 167, 304
Benefits per dollar of costs.....	2. 52	1. 94	2. 09	2. 77	1. 98	2. 24	2. 18	2. 23
Total program costs.....	636, 257	417, 665	863, 669	557, 040	1, 090, 757	3, 565, 383	464, 526	4, 029, 914
Total program benefits.....	1, 605, 842	818, 682	1, 884, 369	1, 514, 877	2, 307, 699	8, 131, 469	1, 162, 861	9, 294, 330
Benefits per dollar of costs.....	2. 52	1. 96	2. 18	2. 72	2. 12	2. 28	2. 50	2. 31

¹ Included for comparative purposes and to round out the picture of a complete program for the entire uplands of the Yazoo watershed. (See H. Doc. 892, 77th Cong., 2d sess.)² Includes conservation or on-site benefits on public land.

